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HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII

Under the joint supervision of the
UNIVERSITY OF HAWAII
and the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION

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(Under the joint supervision of the University of Hawaii and the Office of Experiment Stations, United States Department of Agriculture)

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Honolulu, Hawaii December, 1936

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INTRODUCTION

During the past year the quota restriction on sugar and the self-imposed quota on pineapples have served to limit expansion of these crops and to emphasize the need of other crops and agricultural enterprises in order to promote greater economic stability in Hawaii. Constantly increasing acreage yields of these two major crops have tended to release areas of arable land. Diversification of agriculture offers a means of utilizing such areas and adding to the total income of the Territory as well as of broadening the scope of opportunity for its citizenry.

Steady gains have been made in recent years by local producers in supplying Hawaii's needs in truck crops, poultry, dairy, and beef products. The promising possibilities that have been developed for macadamia nuts and winter potatoes on the

mainland markets offer encouragement for the belief that other products such as taro, papayas, tomatoes, passion fruit, and asparagus will be added to Hawaii's mainland shipments.

Small farming in Hawaii is confronted with numerous obstacles. Its products in the local markets enter into direct competition with carefully graded and packed products from the mainland. It has no practical means of diverting crop surpluses to other localities, which results in fluctuating prices and uncertain markets. Some of the crops which have formed the basis for diversified farming in the past are rapidly declining in acreage, and outside competition threatens the existence of those long established small farming areas based on coffee and rice. There is a pressing need for scientiffc study of the factors of production, disease control, marketing of these crops, together with the development of new crops which have export possibilities to supplant or supplement them. The two private research stations established to furnish a sound scientific basis for the development of sugar cane and pineapple have given ample evidence that new ventures must receive a subsidy of scientific support. It therefore devolves upon the Hawaii Agricultural Experiment Station to aid the small farmer and plantation alike in the field of diversified farming and development of new agricultural industries.

Hawaii, together with Puerto Rico, occupies a unique position in the agriculture of the nation as the two comprise its major tropical areas. Production of those crops which supplement rather than compete with mainland production constitutes an opportunity for future development in the field of diversified agriculture in Hawaii. To this end the work of the Station is stressing development of tropical crops, and the supplying of mainland markets with winter grown produce. Study of tropical phases of scientific investigations, national in their scope, comprise another field of special value in the Station's program of work.

The importance of the Territory in the plan of military defense gives a national aspect to such problems as local production of food, rodent control with respect to health and crop production, and utilization of local foods in the diet. To this

end direct cooperation with various agencies of the Federal Government has been established.

The assignment to the Hawaii Station of $410,000 from the Sugar Processing Tax Funds has made it possible for the Station to extend its activities throughout the entire Territory, and to inaugurate work in the field of animal parasitology, marketing, plant pathology, and veterinary science.

FISCAL STATEMENT

Table 1 gives the itemized statement of the Station's appropriation for the fiscal year beginning July 1, 1935. The total of $100,957.78 of the regular Station funds represents an increase of $7,891.78 over last year's appropriation. This increase is made up largely by the Bankhead-Jones appropriation and additional Territorial funds.

Pursuant to Section 15 of the Agricultural Adjustment Act, approved May 12, 1933, (48 Stat. 31) as amended by the act approved May 9, 1934, (48 Stat. 670) the President, by Proclamation No. 2091 as amended by Proclamation No. 2100 and by Proclamation No. 2127, decreed that a certain amount of the processing taxes collected on Hawaiian sugar should be held as a separate fund to be used and expended for the benefit of agriculture in the Territory of Hawaii, as the Secretary of Agriculture, with the approval of the President, should direct. In behalf of the Territory of Hawaii, the Hawaii Agricultural Advisory Committee, consisting of the Governor of the Islands, a representative of the sugar industry, the President of the University of Hawaii and the local representative of the Agricultural Adjustment Administration, Department of Agriculture, considered means of devoting this fund to the interest of a more efficient utilization of land in the Territory. The Committee recommended, and the President and Secretary approved, the allotment of $410,000 of this fund to the Hawaii Agricultural Experiment Station for the following projects: Taro Investigations, Liver Fluke Eradication, Rat Abatement Campaign, Development of Truck Farming and Improvement of Marketing Facilities for Farm Products, Development of Livestock Feed, Development of Tropical Fruits and Nuts, and Promotion of the Poultry Industry. After January 6, 1936,

when the decision of the Supreme Court invalidated the Agricultural Adjustment Act with respect to the collection and use of processing taxes, the unexpended balances of the funds allotted to these projects were made available in the Supplemental Appropriation Act, fiscal year 1936 (49 Stat. 1116). The allotments were originally set up for one year's activity but are now being spread over a period of approximately 15 to 20 months and will terminate during the spring and summer of 1937.

Table 1.—Disbursements for the fiscal year beginning July 1, 1935.

Regular Funds	**Amount Disbursed**	
Territory of Hawaii	$ 36,595.18	
Congress—through University of Hawaii		
Hatch Act	15,000.00	
Adams Act	15,000.00	
Bankhead-Jones Act	2,296.60	
U. S. Department of Agriculture		
For support of Pensacola Street Station	$ 32,066.00	
TOTAL		$100,957.78

[1]Sugar Processing Tax Funds

Tax Fund Order No.	**Appropriation**		
4 Taro Investigations	$ 50,000.00	25,959.00	
5 Liver Fluke Eradication	40,000.00	12,956.08	
6 Rat Abatement Campaign	110,000.00	32,298.56	
7 Truck Farming and Marketing	60,000.00	16,830.59	
8 Development of Livestock Feeds	70,000.00	10,582.17	
9 Development of Tropical Fruits and Nuts	50,000.00	10,385.34	
10 Promotion of Poultry Industry	30,000.00	5,388.13	
TOTALS	$410,000.00		$114,399.87
GRAND TOTAL			$215,357.65

[1]In addition to numbers 4 to 10, Tax Fund Order Nos. 1 and 2 with an appropriation of $15,000, later augmented by an additional $15,000 (49 Stat. 1116) for a soil survey of the Territory are being administered by the U. S. Bureau of Chemistry and Soils; Tax Fund Order No. 3 with an appropriation of $80,000 for fruit fly control is being administered by the U. S. Bureau of Entomology and Plant Quarantine.

NEW ACTIVITIES

With greater financial support and increased personnel, it has been possible for this Station to start a number of new activities during the year.

Plant Pathology

After a lapse of sixteen years a department of plant pathology has been reestablished. This department is under the leadership of G. K. Parris. During the year investigations have been largely concerned with taro diseases as a part of the Sugar Tax Fund taro project. In addition, it has been possible to make surveys of the chief diseases of a number of truck crops on the islands of Oahu and Kauai.

Horticulture

During the year a new head of the horticultural department was obtained in J. H. Beaumont following the resignation of Willis T. Pope. Under Dr. Beaumont's leadership, investigations are being continued on the most promising horticultural crops with additional emphasis placed on plant selection, purposeful genetic breeding, and physiological studies on dormancy and reproduction. Most of the truck crop work of the Station is likewise a part of this Division.

It has been possible to expand greatly the scope in both horticulture and truck crops with Sugar Processing Tax Funds assigned to these two projects. This expansion has taken form in a number of large scale trials and cooperative tests in the various islands.

Truck Crop Marketing

The inferiority of Hawaiian-grown truck crops as they appear on the markets as compared with the carefully graded and packed imported products has emphasized the desirability of adopting mainland methods. As a part of the Sugar Tax Fund truck crop project, H. H. Warner, now Director of the Agricultural Extension Service of the University of Hawaii, was secured to study the local marketing situation and outline the plans for demonstrations of grading and packing. These

have been made possible through the Tax Funds. Ross H. Gast was employed to direct the project. H. B. Cady was later appointed following the resignation of Mr. Gast, who now heads the newly established Marketing Service of the Inter-Island Steam Navigation Company. Mr. Cady and Mr. Gast have had many years experience in similar marketing work with California truck crops.

Parasitology

The tropics with their year-round temperate climate provide optimum conditions for the growth and spread of animal parasites. Such parasites are known to be causing considerable losses in cattle and poultry in the Territory. Sugar Processing Tax Funds have made possible the setting up of a parasitology laboratory for work on the liver fluke and parasites of poultry. J. E. Alicata and L. E. Swanson were secured from the Bureau of Animal Industry, U. S. Department of Agriculture, to head the projects. The work to date has been so fruitful of results of immediate and practical importance to the poultry industry that there is ample justification for continuation.

Rodent Control

The Sugar Tax Project is being administered by the Hawaii Experiment Station with helpful cooperation by the Board of Health, the Hawaiian Sugar Planters' Association, and the U. S. Bureau of Biological Survey. It was jointly agreed that the experimental phases of the project should be stressed. A laboratory was accordingly set up and equipped to make studies of life histories, lethal doses of various poisons, attractive baits, and an effective method of rodent control with various crops under field conditions.

C. E. Pemberton of the Hawaiian Sugar Planters' Association took charge until his other duties became too pressing, whereupon representatives of the U. S. Bureau of Biological Survey assumed leadership. Effective July 1, 1936, H. G. Hansen was assigned by the Biological Survey as a representative of that organization and the expectation is that a unit will be maintained here for several years or permanently.

Animal Nutrition

Little is known of feeds normally grown in the tropics and sub-tropics and their utilization in the animal body. The Sugar Tax Fund livestock feed project wisely authorized investigations in this field with especial reference to the utilization and digestibility by actual animal trials of the common feeds. A well-planned building was erected for these investigations on the University Farm and animal tests started toward the end of the year. S. H. Work, who previously conducted such investigations at Cornell University, is in charge.

Food Processing

As a part of the Sugar Processing Tax Fund taro project, a laboratory was equipped with machinery of semi-commercial size to develop methods of processing taro into food products. A continuation of this laboratory with additional equipment to adapt it to the study of the processing of a variety of food products constitutes an important part of the Station's general program of developing mainland markets for Hawaiian-grown products. The present quarantine regulations and the perishable nature of many tropical fresh products emphasize the necessity of shipping, wherever possible, in a preserved, frozen, or dried form. The work is, at present, being entirely supported by Sugar Tax Funds. John H. Payne and Gaston J. Ley are in charge of the project.

NEEDS OF THE STATION

The splendid progress which has been made by the various new branches of work financed by the Sugar Processing Tax Funds gives ample evidence of their value to the Station's activities. Most scientific investigations are sufficiently complex to require a varied attack by several specialized departments. An agricultural experiment station's work is badly crippled without adequate treatment of parasitological, pathological, and entomological phases. Scientific investigations relating to new agricultural industries for the Territory should also be accompanied by adequate study of the economic and marketing phases.

The needs of the Station, therefore, include the continuation of the newly created departments with the further addition of departments of entomology and agricultural economics. Several departments are now housed in temporary makeshift quarters. A building program to transfer these scattered activities to the University campus is desirable. Provision for the development of the recently acquired Poamoho Farm on Oahu as well as the substations on Maui and Hawaii is necessary if the Station's work is to be made territory-wide in its scope.

SUMMARY OF PROGRESS

The addition of several new departments and augmentation of the work already established have given a decided stimulus to the Station's activities. A more varied approach and greater facilities for field work have markedly increased the effectiveness and scope of the research work. This summary of progress is supplemented with more detailed reports of departments beginning on page 18.

Taro Investigations. Taro (*Colocasia esculenta*), once an important food crop in Hawaii, has dwindled in the past two decades to a small fraction of its former acreage. The work of the Taro Processing Division gives much encouragement to the idea that a variety of dried taro products can be economically prepared which are pleasing in appearance and flavor. With a mainland market for such products the taro would become of importance not only as a lowland submerged crop but as an upland crop, capable of being grown in cool moist sections and other areas not adapted to sugar cane and pineapples. Disease in the lowland taro, grown submerged, is serious, often causing losses of 40 to 50 per cent of the crop. Pathological investigations are providing basic data on the causal organisms and their control. The Nutrition Department of the Station, the Queen's Hospital and Ewa Health Center are working on the nutritional value of taro and its products and ways of increasing its use in the local dietary. An unwieldy number of more than 140 so-called taro varieties have now been tentatively classified into about 20 groups.

Truck Crops. Genetical and breeding projects are progressing with the sweet potato, lettuce, and tomato. Pathological

surveys have been begun to identify and map the extent of diseases of certain truck crops. Extensive variety trials have been instituted in five of the principal vegetable growing districts. Fertilizer experiments are under way which embrace the most important truck crops and local soil types. Fundamental investigations dealing with the physiological effect of climate and fertilization have been set up as regular Station projects.

A number of promising possibilities have come to light. An unusually desirable sweet corn from Puerto Rico appears well adapted to Hawaiian conditions and is resistant to mosaic disease. The winter potato crop sold at premium prices on the mainland during the past year gives encouragement to the belief that other truck crops may be added to the off season trade.

Demonstrations of the methods of grading of truck crops by U. S. standards and the use of standard shipping containers have aroused the interest of both grower and wholesaler. Tomatoes grown on Maui, when graded and packed by recommended methods, sold at parity prices with the imported article. These demonstrations are being extended to other crops and to the other islands. A general truck crop survey of all the islands was completed and is being kept up to date by a monthly census. It is expected that this will serve as a guide to the grower in determining his planting schedule and assist in stabilizing prices.

Fruits and Nuts. The recently established air express from the mainland and the Orient now make it possible to bring in new introductions of fruits and nuts in the form of scions and rooted plants. Importations of improved varieties of litchi, mangosteen, mango, and citrus have already begun. Intensive study of the physiological phases of growth, flowering, and fruiting, and of the genetic nature of these fruits has been inaugurated to serve as a basis for future selection and breeding work.

Papaya investigations are being given special emphasis due to the obvious need of improvement and standardization of quality and to the possibilities for shipment in some processed form. The methods of preparation of dried, quick frozen, and canned papaya, diced and pulped, alone and blended, are being

investigated. Projects on improvement of the litchi, lungan, passion fruit, and Eugenia have also been initiated.

The macadamia nut industry in Hawaii has thus far been built upon seedling trees. This has resulted in a great variation in tree type, yielding capacity, and nut characters. The future of the industry would seem to be dependent on eliminating or topworking the undesirable trees of the grove. Topworking experiments on ten-year-old trees of the inferior "rough shell" variety with "smooth shell" scions in the Kona District of Hawaii have been started and appear successful. Records of yield, nut quality, and tree characteristics of a large number of seedlings provide the basis for selection of scion wood. The needs of the industry have been further served by investigations of the effect of various phases of the curing process of the harvested nuts.

Continued low prices of coffee are emphasizing the need of reducing production costs. Experimental work on fertilizers, pruning, and dieback are yielding practical results. The new fertilizer formulas based on the Station's experiments having a high potash and a low phosphorus content are now in common usage.

Foods and Nutrition. The Foods and Nutrition Division is rendering a signal service to the Territory and to the general field of nutrition in its studies of tropical foods and the dietary of tropical countries. Such studies include chemical analyses and biological experiments on the common and rarer species of fruits, vegetables, and sea foods. Each of the racial groups which make up the population of Hawaii has characteristics in its diet which relate to that of its mother country. The formulation of balanced diets from Hawaiian grown foods which are acceptable to the tastes of these varied groups has comprised an important part of the work of the Nutrition Division. Investigations during the past year have shown the papaya to compare favorably with oranges in sugars, calcium, ash, and vitamins A and C. The taro contains calcium in a form well utilized by the animal body. The Japanese custom of pickling vegetables with such accessory materials as rice water, sake, miso, and rice bran results in a marked transfer

of vitamin B to the pickled vegetable. The opihi, a widely distributed Hawaiian shellfish, is a highly valuable food and the equivalent of cod liver oil in vitamins A and D.

Forage Crops. Much of the opportunity for progress in beef, dairy, and swine production is dependent upon further development of forage crops in Hawaii. Seed importations from many parts of the world are being tested at the central station in Honolulu, the various upland station plots on Maui, and in cooperation with various ranches. Special emphasis is being placed on the coarse fodder grasses adapted to beef fattening paddocks in the wet areas as well as grasses and legumes adapted to dry conditions characteristic of the leeward side of the several islands. Promising species are *Medicago falcata*, a spreading pasture type of alfalfa from Wisconsin, and 2 species of *Digitaria*, *D. pentzii*, and *D. milangiana* introduced from Australia.

Management of fattening paddocks and soilage crops is being studied by means of frequency of cutting tests of alfalfa and Napier grass (*Pennisetum purpureum*). Results indicate that alfalfa is best cut at about full bloom, which gives 8 to 9 cuttings a year. Napier grass cut at 8 to 10 week intervals gave the best yields of forage with satisfactory palatability and protein content. A cooperative test on Napier grass has been installed in a ranch fattening paddock to determine the fertilizer requirements of the crop.

Rapid deterioration of many varieties of seed in the humid tropics and subtropics constitutes a problem of vital importance to many phases of tropical agriculture. Preliminary experiments on the effect of humidity showed that the effective life of many varieties of seed can be greatly lengthened by reducing the relative humidity to 60 per cent or below.

Livestock. The possibilities of improving the quality of beef and at the same time increasing the carrying capacity of the beef ranches through the medium of fattening paddocks and supplemental feed are being investigated in a series of cooperative experiments with various ranchers. Napier grass, pigeon peas, ekoa, and various grass mixtures are commonly used in such paddocks, but there is no experimental data to show their

comparative value or the value of such supplements as molasses, soybean meal, and fish meal. Cooperative pen feeding experiments with beef animals include pineapple bran, cane bagasse, and cane tops supplemented by protein concentrates. Completed trials show that by-product feeds of the pineapple and sugar industries are more economical in dairy cow rations than imported grains. Pineapple bran and cane molasses substituted for barley in two milk production tests resulted in a 30 per cent saving in cost of concentrate with no decrease in milk production. Molasses poured over roughage increased milk production and appears to be a desirable and profitable practice.

Little is known regarding the actual digestibility of tropical feeds. The coefficient of digestibility (the per cent of the total of any constituent which is actually digested by the animal) is essential in evaluating a feed and compounding feeding rations. An experimental building for digestibility trials has been erected and one trial with Napier grass completed using ten steers in the trial. Other tropical grasses, legumes, and by-products of Hawaiian industries will be used in subsequent trials.

Liver fluke is recognized as a distinct menace to profitable dairying and beef production in certain localities in Hawaii. Surveys have been completed of the infested areas as well as checks on the percentage of infestation. Post mortem examinations have shown that the water buffalo (*Bubalus bubalus*) and the horse may act as hosts for the fluke. The possibilty of certain of the wild animals in the wet forested areas being infested is under investigation. It has been found that the liver fluke prevalent in Hawaii is a different species from that existing on the mainland, the latter being *Fasciola hepatica*, while the one found locally is *Fasciola gigantica*, common in India and other Asiatic countries. Cooperative field experiments with ranchers and dairymen are testing the effectiveness and feasibility of removing sources of infestation by draining, filling, fencing, and copper sulphate treatment of swampy areas.

Poultry. Projects dealing with the use of batteries for laying hens and breeding stock, humidity control in incubators,

the use of locally produced feeds in the rations, and cross breeding for meat production have been initiated. Experiments on artificial illumination during the period of high egg prices have shown greater egg production with no increase in mortality. Compartment batteries for laying hens continue to show economical egg production when fed a commercial egg ration augmented with one per cent refined cod liver oil and fermented yeast mash. Greater percentage hatch and thriftier chicks are obtained if the humidity of the incubation chamber is maintained at about 60 per cent up to the 18th day and 85 per cent at hatching. Freshly cut alfalfa is inferior to alfalfa leaf and blossom meal in poultry rations, causing a greater variability in the intensity of the yolk color and general lack of thriftiness of the hens.

Poultry parasite investigations have been centered largely in the study of the life history and control of the gizzard worm (*Cheilospirura hamulosa*) of chickens and turkeys. This parasite has been found in nearly all flocks in the Territory, causing considerable loss due to anemic conditions and lack of vigor. Heretofore only grasshoppers were known to serve as intermediate hosts of the gizzard worm. The Parasitology Division has been able to show experimentally that 14 different species of arthropods may serve as intermediate hosts. Since certain of the beetles and weevils are found around manure and feed accumulations, careful attention to cleanliness is recommended. Other poultry parasites identified are the spiral stomach worm (*Dispharynx spiralis*), the globular stomach worm (*Tetrameres americana*), the eyeworm (*Oxyspirura mansoni*), and a tapeworm (*Hymenolipis exigua*) not previously reported from Hawaii.

Rodent Control. Laboratory studies were made with rats, mice, and mongooses to provide basic information on attractive food materials for baits, the type of bait package, and lethal dose requirements for the different rat species. One hundred bait formulas using various poisons, food material, and package types were developed, and a total of about 5,000 pounds sent out for field trials on the various islands. Several of the new formulas developed showed a marked superiority

over the baits commonly used in Hawaii. In general, the sausage type with either hamburger or bacon rind as the principal food attractant and thallium sulphate as the poison offers the most promise from the standpoint of cost and effectiveness. A rolled barley, using thallium sulphate and fresh blood dried in the bait as an adhesive for the poison has likewise proved effective. Life habit studies of the four rat species in Hawaii are being made to serve as a basis for more effective control methods. Field trials of new baits are being made on Oahu, Kauai, and Kona, Hawaii.

In addition to experimental phases, field control operations have been conducted on Maui and East Hawaii in cooperation with the Board of Health.

COOPERATION WITH OTHER AGENCIES

The Experiment Station, with its limited facilities, is restricted in the amount of experimental work which it can maintain single-handedly on the outlying islands. Yet it is imperative in many types of experimental work that the tests include repetition under the wide range of rainfall, altitude, and soil types occurring in the Islands. To bridge this gap, cooperation with other agencies, both governmental and private, has been enlisted. Such cooperation has made possible a territory-wide experimental program along such important lines as adaptation of grass species under range conditions. feeding experiments with beef and dairy animals, efficacy of control methods of liver fluke, crop surveys and monthly census of truck crop, and trials of new accessions of tropical fruits and nuts.

Cooperation with Territorial and Federal agencies has been particularly helpful. With the former it has meant the effective coordination of all rodent control and parasitological work. Federal cooperation has made possible general surveys of the liver fluke and rodent situations by leading Department of Agriculture specialists and the loan of specially trained personnel for the duration of the Sugar Processing Tax Projects.

Following are listed those agencies with whom the Station established cooperation during the year:

Federal Government

Army—Surveys of local food situation; tests on taro flour

Biological Survey—Rodent control project; establishment of a local unit of the Biological Survey in Hawaii

Animal Industry — Survey of liver fluke situation; loan of scientific personnel

Agricultural Economics—Fruit and vegetable grading; establishment of a permanent cooperative service in the Territory

Territorial Institutions

Board of Health—(Maui and Hawaii) Rodent control project

Waialee Training School for Boys—(Oahu) Taro culture and variety tests

Hawaiian Homes Commission—(Molokai) Taro culture and variety tests

Queen's Hospital and Ewa Health Center—Education in the use of taro in the diet

Sugar Plantations

Maui—Taro culture and variety tests (Maui Agricultural Co., Ltd.)

Oahu—Livestock feeding tests (Waialua Agricultural Co., Ltd.)

Oahu—Livestock feeding tests (Waianae Company)

Small Farmers

Hawaii—Commercial improvement of macadamia nuts (K. Sasaki)

Hawaii—Commercial improvement of macadamia nuts (H. S. Kim)

Oahu—Taro culture and variety tests (J. K. Jones)

Oahu—Taro pathological experiments (Wong Nin)

Ranches and Dairies

Hawaii—Livestock feeding test (Kapapala Ranch)

Hawaii—Napier grass fertilizer experiment (Keaau Ranch)

Oahu—Liver fluke control experiment (Kualoa Ranch)

Oahu—Liver fluke control experiment (Hygienic Dairy)

PERSONNEL

Additions to Staff

The increased funds made possible the engagement of a number of well-trained, young and active investigators and an expansion of personnel from 27 full- and part-time appointed employees in 1935 to a total of 83 in 1936. The following have been added to the station during the past fiscal year. Most of these employees are on a temporary basis:

J. E. Alicata, Parasitologist—Liver fluke and poultry parasites

N. F. Ambrose, Assistant Agronomist—Truck crop marketing

J. H. Beaumont, Principal Horticulturist—Head, Horticultural Division

F. A. Bowers, Principal Agricultural Aide—Taro investigations

A. W. Burt, Principal Agricultural Aide—Livestock feed project

H. B. Cady, Marketing Economist—Truck crop marketing

Oliver Crosby, Principal Agricultural Aide—Livestock feed project
F. A. Elliott, Sr. Scientific Aide—Rodent control
R. H. Gast, Marketing Economist—Truck crop marketing
Wendell Jordan, Sr. Scientific Aide—Rodent control
G. J. Ley, Chemical Engineer—Taro investigations
R. A. Lyman, Supt., Haleakala Substation
R. H. Moltzau, Principal Scientific Aide—Fruits and nuts project
G. K. Parris, Associate Plant Pathologist—Taro investigations
J. H. Payne, Associate Chemist—Taro investigations
C. E. Pemberton, Principal Biologist—Part-time, Rodent control
M. Potgieter, Associate Chemist—Taro investigations
H. J. Spencer, Assistant Biologist—Rodent control
L. E. Swanson, Associate Parasitologist—Liver fluke project
J. C. Thompson, Principal Scientific Aide—Truck crop investigations
B. A. Tower, Assistant Poultry Husbandman—Poultry husbandry
H. H. Warner, Principal Marketing Specialist—Part-time, Truck crop marketing
L. D. Whitney, Assistant Agronomist—Taro investigations
C. L. Wilbar, Jr., Senior Medical Officer—Part-Time, Taro investigations
S. H. Work, Associate Animal Husbandman—Livestock feed investigations

Separations

H. F. Willey, Superintendent of the Haleakala Substation, resigned December 31, 1935, to become County Agent with the Agricultural Extension Service.

John Castro, Plant Propagator, died on February 25, 1936, after 27 years' service.

C. E. Pemberton, Principal Biologist, in charge of the Rat Abatement Project, resigned on March 7, 1936.

Ross H. Gast, Marketing Economist, resigned on April 24, 1936, to become manager of the Inter-Island Growers' Service.

Willis T. Pope, Senior Horticulturist, resigned effective June 30, 1936, as a member of the Horticulture Department of the Station and as a professor in the University of Hawaii.

LAND AND BUILDINGS ACQUIRED

The offices of the Experiment Station were transferred on August 1, 1935, to the new Agricultural Building erected on the University campus (Plate 1). This two-story, concrete block building has a floor space of approximately 14,400 square feet and is used by the Agricultural Experiment Station and Agricultural Extension Service. In addition to the main

office, four department heads of the Station have their offices in this building. There is also a laboratory for instruction in soils and a chemical laboratory.

Plate 1.—New Agricultural Building, which now houses a part of the Station staff, a chemical and soils laboratory. Here are also located offices of the Agricultural Extension Service and instructional classrooms of the Agricultural Department.

The site for the Station's experimental farm, consisting of 30.766 acres of territorial land was set aside for the use of the Station by Governor's Proclamation No. 695 on February 28, 1936. This land is situated on the main highway midway between Wahiawa and Waialua, and has been used for pineapple and sugar cane culture. It will be available to the Station at the expiration of the present lease on August 30, 1937. Irrigation water is available and the area to be known as Poamoho Farm will be used for investigations on soils, forage crops, truck crops and some tree crops.

A model barn was erected on the University Farm to house animals and to provide office and feed room space for digestion experiments. This building has 10 adjustable stalls which can be used for animals such as pigs, sheep, steers, or cows.

A pre-fabricated steel-frame greenhouse 25 by 50 feet was erected for use of the plant pathology department. A headhouse, 25 by 40 feet adjoins the greenhouse and will be used for storage of materials and laboratory work associated with the greenhouse.

The Haleakala Substation of 38 acres has been used by the Experiment Station and its predecessor, the States Relation Service, since 1922 without formal land transfer. This substation will be used in the future by the Experiment Station and a formal land transfer was obtained by Governor's Proclamation No. 677, dated December 17, 1935.

Leases were obtained on buildings to serve as temporary quarters for parasitology, food processing, and rodent control investigations. These buildings are makeshift accommodations, entirely inadequate for the needs of the work.

REPORT OF DEPARTMENTS

AGRONOMY

Seed Viability

Low humidity increases life of seed in storage. In the humid tropics and subtropics many varieties of seeds quickly lose their ability to germinate. With a few seeds this problem makes it difficult to maintain viable seed supplies from harvest to the next planting season. To study the factors operating and to devise better methods for storing seeds under island conditions, investigations were begun in the fall of 1935. In a preliminary experiment of 250 days storage at room temperatures of about 75° F. and with a relative humidity of 90 per cent, soybeans, garden beans, and lettuce had zero germination while at 75 per cent relative humidity these same seeds had 97, 87, and 34 per cent germination respectively. Corn, scarified alfalfa, and rice were also tested with very low germination after storage at 90 per cent relative humidity. Storage at 60 per cent relative humidity or less resulted in good germination at the end of the 250 day period. The mean relative humidity at Honolulu is 72 per cent at 8 a. m., 66 per cent at noon, and 73 per cent at 8 p. m., with only slight seasonal departures from these means. The above results indicate that seeds should be stored at relative humidities below 60 per cent if possible. (Wilsie and Akamine)

FORAGE AND PASTURE CROPS

New Introductions. Twelve seed samples of legumes, 10 of miscellaneous herbage plants, and 60 of grasses were added to the forage nursery. A number of species of *Medicago* and *Trifolium* from Palestine grew in the nursery for a few months and finally died, not being adapted to the relatively dry, hot conditions at the Pensacola Street Station. A spreading pasture type of *Medicago falcata* introduced from the University of Wisconsin gave promise of producing excellent yields of seed and possible value for pasture mixtures.

Four varieties of molasses grass (*Melinis minutiflora*) from Brazil were tested and none found to offer more possibilities than the ordinary type called "Roxo" or "Violet" in Brazil. Molasses grass is rapidly becoming popular in Hawaii on account of its ease of establishment with or without soil preparation, and also because of its fattening qualities once cattle have acquired a taste for the grass. A large number of other grasses were introduced through the courtesy of the Soil Erosion Service and while it is too early to say which ones will be promising, a few, especially the Panicum species, appear to have possibilities. Several have already been eliminated because under Hawaiian conditions it appeared that these might become serious pests if allowed to become naturalized. These included *Agropyron smithii*, *Chloris berroi*, and *Andropogon ischaemum*.

Alfalfa should be cut at part bloom to full bloom stage. The frequency of cutting experiment started in January 1934 was completed in August 1935. At that time the stand suddenly became badly depleted due primarily to a heavy infestation of nut grass (*Cyperus rotundus*) with which the alfalfa was unable to compete. The life of alfalfa on bottomland soils, relatively poorly drained and heavily infested with weeds, is often less than two years. On fields free from nut grass and under fairly dry conditions, however, stands may last for eight years or more. In this experiment the yields were good during the course of the first year after the cutting treatments were begun as shown in Table 2.

Table 2—Effect of frequency of cutting on the yields of alfalfa at the University Farm.

Cutting treatment	Number of cuttings	Growing period	Green weight per acre	Air-dry weight per acre
		Days	Tons	Tons
Bud stage	12	31	26.1	5.6
One tenth to one quarter bloom	10	37	39.8	9.5
Full bloom	9	43	49.3	11.1

While the test did not run as long as was desired, the results show plainly that higher yields are obtained with alfalfa when it is cut in full bloom or in the tenth to quarter bloom stage than when cut in the bud stage. Under Hawaiian conditions, therefore, it is probably preferable to cut eight or nine times per year as a maximum rather than 11 or 12 times as has often been recommended. Alfalfa is used almost entirely as green fodder so that loss of leaves and palatability is not so important as it would be if hay were the product desired. (Wilsie, Whitney, and Takahashi)

Soy beans produced high yields during the summer. Forty-two varieties of soy beans were compared for seed and forage yields. The summer crop harvested in August and September

Table 3—Comparative yields of 14 varieties of soybeans grown at the Pensacola Street Station, Honolulu

Variety	Yield green forage per acre	Yield of seed per acre	
	Tons	Pounds	Bushels
Brown	12.8	4,152	69.2
Tokio	15.2	4,084	68.1
Nanking	14.0	3,505	58.4
Mammoth Yellow	14.4	3,369	56.2
Black F.P.I. 80495	13.1	3,335	55.7
O-too-tan	22.1	3,097	51.6
Tar Heel Black	10.6	3,029	50.5
Selection 2567-2-11	12.6	2,756	45.9
Laredo	12.4	2,620	43.7
Selection 2567-2-1	12.6	2,586	43.1
Seaweed	11.1	2,586	43.1
Biloxi	14.2	2,212	36.8
Virginia	10.3	2,178	36.3
Yellow Biloxi Hybrid	15.1	2,076	34.6

1935 was excellent, the highest yields ever recorded at the Station being obtained. Table 3 gives the yields of the 14 highest yielding varieties, each variety being replicated four times during the experiment.

Fourteen varieties were planted during the winter season at the University Farm. Grown at that time of year, the plants were much smaller with only the O-too-tan exceeding 18 inches in height. Early and late varieties matured within two weeks of the same date, and yield and quality of seed due to unfavorable weather conditions were poor. (Wilsie)

Frequency of cutting of Napier grass affects yields and quality of forage. Yields under the various cutting treatments from March 1, 1935, to July 1, 1936, varied from 14 tons of air-dry forage per acre with cutting intervals of 6 weeks to 31 tons per acre with 14-week intervals. The forage cut at 6-week intervals is 100 per cent palatable while that cut at 14-week intervals is only about 40 per cent palatable due to the coarse stalks and high fiber content at this stage in growth. Cut every six weeks, however, the plants do not appear vigorous and it is questionable just how long a stand can be maintained. Present indications are that cutting at 8- or 10-week intervals will be a more practical procedure giving high yields and fairly palatable forage.

Chemical analyses were made on 50 samples taken from each cutting treatment at various succeeding cuttings as the experiment progressed. Preliminary results indicate a rather low protein content of 4 to 5 per cent from all cutting treatments with the exception of those plots cut every 6 weeks. With this latter treatment the protein content was about 8 per cent which does not exceed that of ordinary grass meadow hays.

Yield studies were continued with nine selected seedling strains. Certain morphological differences between these strains are apparent, but yields so far do not appear to be significantly different. (Wilsie and Takahashi)

Cassava and edible canna. Plantings of several varieties of cassava (*Manihot utilissima*) and edible canna (*Canna edulis*) were maintained. Cooperative plantings of two varieties of cassava (Florida No. 1, and Wiebke) were made near Wahi-

awa and Waialua on Hawaiian Pineapple Company land. These plantings, although put in under dry and somewhat unfavorable conditions, did well and showed a considerable range of local adaptation for this starch crop.

TARO

The agronomic investigations with taro (*Colocasia esculenta*) have included three phases: (1) Varietal and taxonomic studies, (2) Survey of field production, and (3) Field experiments involving variety and fertilizer tests.

Taxonomic scheme of classifying taro varieties developed. Taro is one of the oldest Hawaiian crops and there exist in the Territory more than 100 so-called varieties. There has been little attempt in the past to work out a taxonomic scheme of classification and little is known about what actually should constitute a variety. During the past year the collection of taro varieties at the Station has been increased until it contains more than 140 introductions which probably represent at least 80 distinct forms. (Plate 2.) Physical measurements, photographs, and descriptions of each so-called variety have been made. Color has been found to be of great importance in identifying distinct types. Considerable progress has been made in the task of placing all of the available forms in a logical taxonomic classification. It is felt that all forms will probably be placed in about 20 varietal groups having certain distinctive features. There seems to be no taxonomic distinction between wetland and upland taros, the physiological adaptation to wet or dry culture being the principal difference between the two types.

A survey of taro areas has also been in progress. This has included an estimate of acreage, varieties used, source of water, cultural methods, and presence or absence of diseases. When completed, this survey should add considerable information concerning the existing status of the taro crop in Hawaii. Several field experiments involving variety tests and fertilizer requirements were established on the different islands. None of these has been harvested as yet.

Nursery plots of all varieties were harvested in the spring of 1936 and in cooperation with the Chemistry and Soils Divi-

Plate 2.—Taro variety nursery at the Pensacola Street Station containing a collection of 140 varieties.

sion considerable data were obtained in regard to physical characteristics of varieties, adaptability for poi and flour manfacture, development of acidity in poi, comparative viscosity, etc., which will be discussed later. (Wilsie, Whitney, Bowers)

Truck Crop Breeding and Variety Trials

Genetic studies with sweet potatoes. Through the courtesy of Dr. E. S. C. Handy of the Bishop Museum, Honolulu, a large number of native Hawaiian varieties were added to the nursery at Pensacola Street. Sixty varieties, 24 hybrids, and 40 seedling selections were grown in small plots and a complete description of the gross morphological features of each was made. The origin of the many Hawaiian varieties is obscure. While commercially the sweet potato is propagated almost exclusively by vegetative means, because of the profuse flowering in subtropical environments, considerable seed is produced. This results in the presence of numerous chance seedlings in old fields and may be the explanation of many of the varieties now present in Hawaii. Considering the federal market grades as a standard, there are few varieties in Hawaii that are suitable for the present market requirements. Many of the

Hawaiian varieties are red-skinned, of irregular shape, and have a flesh that is dry, woody, or stringy. The best possibilities for improvement at the present time lie in some of the seedlings selected for yellow to cream colored skin with a medium size root tuber and good quality of flesh.

In preliminary fertility studies it was found that most varieties and seedlings are self-sterile under natural conditions. With hand pollination the degree of self-fertility varied from 0-50 per cent. In many cases self-fertility is practically impossible in nature because of the structure of the floral organs, the anthers being definitely below the stigma.

Preliminary work on chromosome studies was initiated with both flower and root-tip materials. Difficulty was experienced in obtaining the proper stage in microsporocytes for the counting of chromosomes. With root-tips, however, one slide was made which showed clearly 90 chromosomes. This number checks with that found by Dr. R. Ramford, University of Maryland, reported to us through correspondence. (Wilsie, Takahashi)

Lettuce breeding. Five varieties and 11 selections of F_3 1801 x mignonette hybrids were grown in field plots. An excellent crop was produced although at low elevation the heads are never as solid as would be desired. Two selections from the 1801 x mignonette hybrids showed promise of becoming valuable for low elevation conditions. Unfortunately, because of the frequent rains most of the plants died before seed was mature, necessitating the use of the 1935 seed crop again next year for the variety plantings. (Wilsie, Takahashi)

Potato variety trials. No variety tests were carried on during the summer of 1935. Seed stock harvested at the Haleakala Substation in March 1935 was placed in cold storage and left there until September 1935. Variety tests were then planted at the Substation including 12 varieties with five replications in the random block arrangement. Yields are given in Table 4, the potatoes being harvested in January 1936.

With the exception of British Queen, all varieties were originally introduced as certified seed. Field roguing was practiced and as indicated by the yields the seed stocks were main-

Table 4—Yield of potato variety tests at Haleakala Substation, Maui.

Variety and Origin	History of Seed Stock	Yield per acre Cwt.
Triumph (Montana)	Grown 2 generations on Maui	97.3 ± 8.5
British Queen	Maui seed stock	93.5 ± 8.2
Earliest of All (Oregon)	4 generations on Maui	92.1 ± 8.0
Katahdin (Oregon)	4 generations on Maui	91.3 ± 8.0
Triumph 19-22 (Nebraska)	3 generations on Maui	88.5 ± 7.7
Early Rose (Oregon)	4 generations on Maui	87.7 ± 7.6
Triumph 23-25 (Nebraska)	3 generations on Maui	87.2 ± 7.6
Triumph 4-12 (Nebraska)	3 generations on Maui	80.5 ± 7.0
Burbank (Oregon)	4 generations on Maui	73.2 ± 6.4
Triumph (Nebraska)	4 generations on Maui	65.7 ± 5.7
Triumph (Louisiana)	3 generations on Maui	60.8 ± 5.3
Triumph (Nebraska)	1 gen. Hawaii; 3 gen. on Maui	34.0 ± 3.0

tained with considerable success. These yields are approximately as good as have usually been obtained in that region even with new certified seed. (Wilsie)

Tomato variety trials. Six varieties including 12 strains were grown in randomized blocks with 6 replications. The season was unfavorable and there was a high degree of flower drop due primarily to frequent rains and insect infestation. All plots were heavily infested with leaf hoppers, melon flies, and the corn ear worm. The crop yields now being harvested are poor. (Wilsie, Takahashi)

New variety of sweet corn recommended. A new variety of sweet corn, U.S.D.A. No. 34, was introduced from the Puerto Rico Station. Two generations have been grown with much success. The quality was good, ears large, and kernels sweet; and the plants appeared to be vigorous and healthy. So far there has been little difficulty with corn mosaic which infests most sweet corn varieties so badly under Hawaiian conditions. Twenty pounds of seed have been distributed for increase purposes. (Wilsie)

HORTICULTURE

The horticultural research program includes work on a wide range of fruits, nuts, and vegetables. The methods of attack are determined by the nature of the problems and in-

clude: breeding and selection including importation; species hybridization including cytological analysis; physiology of growth, flowering, and fruiting; season, soil, and climatic adaptation; asexual propagation and nursery practices; and field culture and nutrition.

Rooted Plants and Scions Introduced by Air Express

Emphasis is being placed upon the introduction, so far as possible, of scions and rooted plants of definitely described varieties of fruits and nuts which seem to have promise in Hawaii from the standpoint of commercial development or of the home garden. The introduction of litchi, mangosteen, citrus, and mango varieties is being undertaken first. Air express from the Orient and the mainland is now making this possible.

Eight varieties of litchi, two rooted plants each of four varieties, and 12 scions each of 4 other varieties, were received from Prof. Puiman Lee of Lingnan University. Five of the rooted plants have started active growth and the grafts made from the scions appear to be doing well. Scions of ten varieties of citrus were received from Dr. H. P. Traub, of the Citrus Experiment Station, Orlando, Florida, and at least one plant of the three grafts made of each variety is growing. Seed and plants of selected Macadamia varieties listed by Mr. W. R. Petrie of Queensland, Australia, have been ordered but have not been received. Mangosteen seed and plants are expected from Puerto Rico and from the Philippines. These and previous introductions are being propagated as rapidly as possible and will be set out in different locations with interested growers.

FRUITS

Papaya

Selection of strains. The blossoms and fruits from 250 seedling trees representing 10 different accessions received by the department in the past from many different sources have been described for color, shape, thickness of flesh, flavor, texture, etc., as well as blossom type in an effort to determine the variability within different strains and to select breeding ma-

terial. In addition, many fruits representing commercial Hawaiian types have been described and analyzed. Approximately 1,500 seedlings from the best of these fruits are being grown for further analysis.

Variable blossom type affects character of fruit. Except in the pure female, the papaya tree may bear several types of blossoms on the same inflorescence. (Plate 3) The type of blossom determines, in some degree, the form and shape of the fruit. A

Plate 3.—Various types of inflorescence of the papaya. (a) Female inflorescence. (b) Elementary type of hermaphordite blossoms having only five stamens. (c) Intermediate or unstable type showing pistilloidy and intermediate number of stamens between 5 and 10. (d) Same as above except that one of lateral blossoms is similar to terminal and the remaining 2 are similar to e. (e) Normal hermaphordite having 10 stamens and normal pistil. The lateral blossoms may be male i.e., the pistils may be rudimentary.

study was instituted to determine to what extent the blossom type might be fixed by controlled breeding. Among 560 plants studied in a commercial planting of papaya of the so-called Solo strain, it was found that less than one-third were pure female and considerably more than two-thirds exhibited varying degrees of hermaphroditism. While femaleness varied within narrow limits from tree to tree, the hermaphrodite types are extremely variable and apparently influenced markedly by seasonal and nutritive conditions. The types are, how-

ever, sufficiently distinct to enable classification. These types are being self-pollinated and suitable crosses made to determine whether different types may be fixed and made to breed true as well as to study the inheritance of other fruit and tree characters. (Beaumont)

LITCHI AND LUNGAN

Approximately one thousand stocks of litchi and lungan are being grown in the nursery at the Pensacola Street Station and at Kona to be used in propagating varieties of these fruits for test in various locations and for various cultural studies. Propagation of the litchi and lungan, like the Macadamia, is very difficult. It is planned, therefore, to use many of these stocks for physiological and anatomical studies of the stocks, scions and graft unions in an effort to determine some of the more important factors affecting successful grafting, such as age and physiological condition of stock and scion, particularly with respect to storage materials and the effect of stimulants in inducing active growth. (Beaumont, Jones, Storey)

PASSIFLORA AND EUGENIA

The chromosome number in 12 species of Passiflora is given in Table 5.

Table 5—Chromosome numbers of twelve species of Passiflora.

Series	Chromosome number	
	n	2 n
P. alba	9	18
P. edulis	—	18
P. edulis forma flavicarpa	9	18
P. foctida	10	20
P. foctida var. Gossypifolia	10	—
P. laurifolia	9	18
P. ligularis	—	18
P. maliformis	—	18
P. pfordtii	—	18
P. seemani	9	18
P. suberosa	12	24
P. vitifolia	9	18

A number of inter-specific crosses has been made and a fair yield of seed obtained. This seed will be grown and the chro-

mosome numbers determined from the root tips. Morphological studies of the chromosomes are being made and the inheritance of various species characteristics will also be followed in order to associate the inheritance of species characters with definite chromosomes. The time required for fertilization after pollination and the time of first cleavage division are being studied previous to attempting special treatments designed to induce multiplication of the chromosome numbers in the species hybrids. In addition to contributing much to the knowledge of the cytology of species hybrids such studies may lead to the production of high yielding, vigorous, and high quality types.

The chromosome number in several of the Eugenia species is being determined as well as in other genera of the family Myrtaceae. Cytological investigations of this group of plants have not been undertaken heretofore and it is believed that such studies as well as species hybridization may lead to interesting and important advances in fruit genetics. (Storey)

Avocado and Mango

This Station, as well as interested growers, has made large collections of mango and avocado varieties in the past years. These plantings are maturing and it is now possible to make accurate descriptions of varieties as grown under different climatic and soil conditions. A number of mango varieties has already been described but it is hoped to broaden this work to include the same and additional varieties from other islands or locations in order to determine under what soil and climatic conditions the mango develops highest market and table quality. Similar studies are in progress with the avocado.

Avocado and mango stocks are being grown in the nursery at the Pensacola Street Station with a view to propagating the more promising varieties of these two fruit plants for more detailed studies. Variety collections will be set out with several cooperators to determine further the climatic and soil requirements of specific varieties as well as for cultural studies affecting fruiting and for studies of fruit-bud formation and annual bearing. (Beaumont, Storey)

CITRUS

Several new and outstanding varieties of the different types of citrus fruits have been introduced. These will be propagated and set out with cooperative growers for comparison with the older standard varieties. Citrus culture in Hawaii, however, appears to be quite dependent upon soil and climatic conditions. Consequently, it is planned to establish citrus variety tests at different elevations and exposures and to use several rootstocks with each variety. Rootstocks, including sour orange, rough lemon, shaddock, and Hawaiian orange, are being grown in the nursery for the propagation of the varieties for these tests. (Beaumont, Storey)

MACADAMIA NUT INVESTIGATIONS

Macadamia seedlings show great variation. Even though selection was begun late in the season, a number of promising types were found. The best of these averaged 42 per cent kernel on a dried basis, which compares favorably with some of the

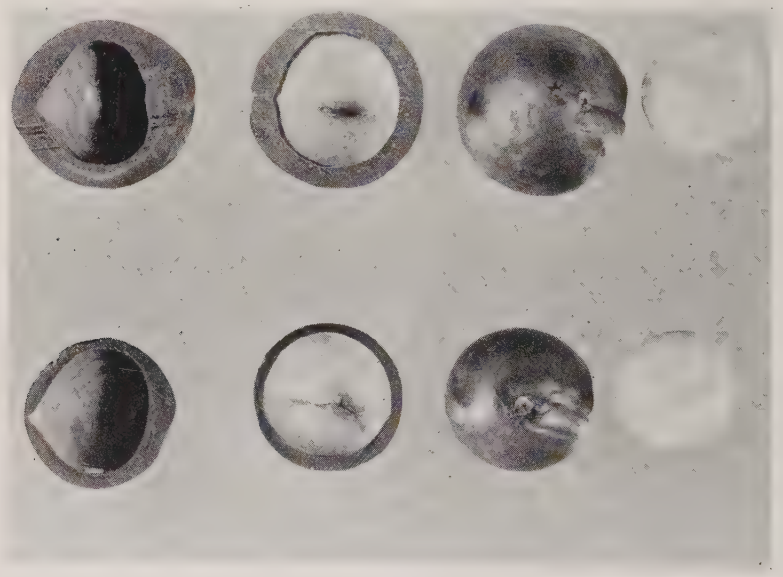

Plate 4.—Variation in Macadamia nuts from seedling trees. Within a single grove, the proportion of kernel varied from 18 to 42 per cent. Excessive thickness of shell as illustrated by the specimen above adds greatly to the cost of handling and processing with no increase in size of the kernel over the specimen below.

best varieties described by Mr. W. R. Petrie of Queensland, Australia. Results of the first season's work with the smooth shell type (*Macadamia ternifolia* var. *integrifolia*), showed nearly 60 per cent of the seedling trees described to have 30 per cent or less kernel and 26 per cent to have 25 per cent or less kernel, the total range being from 18 per cent to 42 per cent kernel. (Plate 4) There was no correlation between size of nut and specific gravity of kernel or between the per cent kernel and specific gravity. Previous work has shown the oil content of the Macadamia kernel to be inversely proportionate to its specific gravity. Large size or thin shell may thus occur in nuts with either high or low oil content. This is important in selecting for quality. Individual tree samples of the rough-shell type (*Macadamia ternifolia*) are definitely inferior in oil content, in color of kernel before and after roasting, but not necessarily in the ratio of kernel to shell. The types described by Mr. Petrie have been ordered for comparison with those selected here.

Plate 5.—Topworking a ten year old Macadamia nut tree. Side wedge graft 3 months after grafting. The top of the stock is to be cut back gradually to the point of union between stock and scion. Smooth-shell scion on rough-shell stock.

Topworking of least desirable type trees in commercial groves. The individual tree descriptions show that many trees are undesirable both in habit of growth and in character of nut. A topworking experiment, situated in four different groves, representing four different ages or conditions of tree, was initiated to determine the feasibility of working over undesirable type of trees to selected varieties. Recognized methods of topworking were employed. (Plate 5) In general, all forms of grafting

were more successful in the Kona District of Hawaii than in of Hawaii than in the Nutridge Grove on Oahu. It seems the Nutridge Grove on Oahu. It seems apparent, however, that topworking may be safely done. Observations on the growth and fruiting of topworked trees will be followed in later years.

Nursery propagation. Experiments to determine the proper season, age and size of stock, and type and condition of scion most suitable for propagation are in progress. In addition the uniformity of seedling stocks and the variations in root systems between different groups are being studied with the view to selecting the most promising stocks for propagation work. Various stimulants, which it is hoped will induce callusing and active growth of scions as well as induce root formation by the stock, are being tested not only with Macadamia but also with litchi and mangosteen, all of which are difficult to propagate.

Variety tests and adaptation studies. Several thousand seedling stocks are being grown in the nursery at Kona and at the Pensacola Street Station. Selected varieties will be grafted on these stocks and later will be set out as variety collections in different locations for comparative adaptation tests. Two or three of the most promising varieties will be propagated in such numbers that comparative cultural and training tests may be established in two or more locations. (Beaumant, Moltzau)

VEGETABLES

Variety tests of truck crops begun on Hawaii, Maui, and Oahu. Two hundred and forty-two varieties, representing a number of different types of truck crops, have been accumulated for test at various elevations and on different soils in the Territory. Four locations have been established: Kamuela, on the island of Hawaii, elevation 2,700 feet; Haleakala Substation, on the island of Maui, elevation 2,100 feet; Waipahu, on the island of Oahu, elevation 300 feet; and at Waialee, on the island of Oahu, elevation approximately 50 feet. In addition to elevation and temperature, these locations also vary in rainfall, light conditions, and soil type. Successive plantings at

each location will be made in order to observe the effect of seasons on growth and yield of the different vegetable crops and to better determine the disease resistance, yield, and quality of varieties. (Beaumont, Welch, Thompson)

Cooperative arrangements have been made between the departments of Chemistry, Agronomy, and Pathology to develop pest-control and fertilizer programs.

Nitrogen requirements of the tomato. The tomato is one of the most important truck crops. This plant is extremely susceptible to variations in soil and climatic conditions, which affect growth and yield. Tests are being established at the Haleakala Substation and at Waipahu to determine the nitrogen requirements of this crop when grown under different nutritional and light conditions. Nitrogen and phosphorus will be varied independently to determine the optimum treatment necessary for best growth, flowering, and fruiting. The potassium will be maintained at a constant level throughout. (Beaumont, Jones)

PLANT PATHOLOGY

The services of the pathologist have been at the disposal of the various county agents of the Agricultural Extension Service and the Experiment Station, and diseased material of a wide range of crop plants has been examined and control recommendations made. Trips have been made to the islands of Kauai, Maui, and Hawaii, and field surveys of the diseases of taro and vegetables completed for Kauai and Oahu. Similar surveys of the other islands are nearly complete. Research work of the department has comprised two projects, pathological investigations on taro and diseases of the tomato.

DISEASES OF THE TARO

The taro plant in Hawaii is grown either as an irrigated crop (wet-land taro) or as a non-irrigated crop (upland taro). The latter type grows best in localities where precipitation is upwards of 100 inches a year. Taro is a relatively long seasoned crop, with twelve to fourteen months as the period of growth. The taro plant is subject to a number of diseases of corm and leaf, with diseases of the corm taking an annual toll of from 25 to 50 per cent wherever taro is grown under

irrigation. Leaf spotting organisms sometimes cause much leaf destruction, but owing to the rapid growth of the plant are not considered to have the economic significance of the corm rots.

Two Major Types of Corm Rot

Two major, distinct corm rots affect the taro plant. The

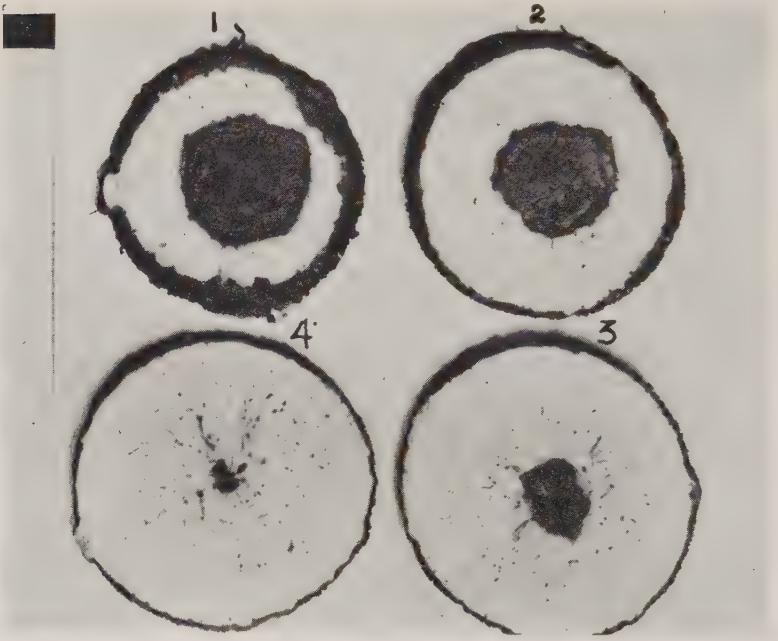

Plate 6.—Internal hard rot of the taro. Cross sections of the taro corm showing the progressive development of the disease from the base (1) toward the apex (4). The diseased tissues are transformed into hard, woody, brownish yellow areas.

first of these, a mushy, malodorous rot commonly called "soft rot" starts from the end or lower side of the corm and may cause partial or complete loss of this underground portion of the plant. From this type of rot two Phycomycetous fungi have been isolated, one a Pythium as yet unidentified but thought to be the same as mentioned by Carpenter[1] and by

[1]Carpenter, C. W. "Suggestions for reducing losses from taro rot," Mimeographed Sheet No. 11, Hawaii Agricultural Experiment Station Annual Reports, 1917-1918.
[2]Wright, J., "Root rot of Cocoyams," pp. 184-197, 1930. Department of Agriculture Gold Coast Year Book 1930.

Wright[2] and the other *Phytophthora colocasiae*, Rac. The latter is a common leaf pathogen of taro of the irrigated type in Hawaii. *Bacillus caratovorus* usually accompanies *Pythium* sp. and *P. colocasiae* as a secondary pathogen. The second type of rot called "internal hard rot" or "guava seed" transforms the internal vascular system of the corm into a hard, woody, yellowish-brown to dark brown mass, useless for making poi, (Plate No. 6) The term "guava seed" arises from the resemblance of the rotted portion in its early stages to the seed of this tropical fruit (*Psidium guajava*). All isolations from diseased material have been negative and stained microtome sections have also revealed no pathogen within diseased tissues. The possible virus or physiological nature of this disease is under consideration. Foliar symptoms of these two diseases are practically absent except for an occasional yellowing and stunting of the affected plants. These symptoms vary with taro varieties and cannot be relied upon with any degree of accuracy.

A third type of rot occasionally encountered, but of more importance as a storage rot than as a field rot, is caused by *Sclerotium rolfsii*, easily identified by its characteristic sclerotia. In only two cases has this fungus been obtained from corms showing soft rot. (Parris)

Transmission of Rot Organisms a Complex Process in Submerged Soils

Laboratory investigations have shown that *Pythium* sp. and *Phytophthora colocasiae* are relatively weak pathogens of the taro corm. Pot tests have confirmed laboratory work with *Pythium* sp. Taro grown in sterilized soil later infested with *Pythium* sp. makes excellent growth, comparable with growth obtained in sterilized soil, and much better growth than taro grown in non-sterilized soil. Except for a few diseased roots, taro in infested soil remains healthy. Both organisms are affected by the pH of the medium. Laboratory tests have shown that *Pythium* sp. does not grow readily below pH 5: [illegible] Losses range from 40 to 100 per cent due to corm rot when the pH of the soil is at or above the neutral point. (Parris)

Drying of Taro Soil the Best Method of Disease Control

All attempts to reproduce the corm rot as seen under field conditions have failed. The rot as seen in the field is believed to be due to the combined action of the two Phycomycetous fungi, either separately or together and soil conditions unfavorable for the growth of the plant. In a saturated, poorly aerated soil, high concentrations of carbon dioxide and other gases together with toxic substances undoubtedly play a part in reducing the natural resistance of the taro corm to attacks from microorganisms. This belief is substantiated by the results of a few growers who have been able to reduce losses by drying and plowing their taro soil for periods of from two to four months. This practice, involving as it does a lapse of time between plantings, is not favored by the average grower, and at present is not usually followed. The return of all diseased material to the taro soil, a common procedure of most growers, if eliminated, would reduce the microorganismal population of the soil.

Disinfestation of the taro soil has been attempted in control of corm rot. Substances applied to the soil for this purpose include sulphur, copper sulphate, lime, acetic and sulphuric acids, borax, mercuric chloride, chloropicrin, semesan, formaldehyde, and tetrachlorethane. Applications have been at various concentrations and at different periods in the growth of the plant as well as prior to planting. The best time of application would seem to be prior to planting during plowing and cultivation of the soil. No field data on treated plots are as yet available. Applications of copper sulphate in the irrigation water have been tried but without encouraging results due to unevenness of spread of the chemical over the soil. (Parris, Bowers)

Use of Clean Planting Material and Resistant Varieties Offers Possibilities for Disease Control

There is preliminary evidence to show that internal hard rot may be transmitted through the huli, or planting material of the taro plant and that hulis from corms showing this disease reproduce the disease in the succeeding crop.

Certain varieties of taro in Hawaii show resistance to corm rots. Upwards of 50 taro varieties are being grown in localities where disease is a major factor in production. Results will be forthcoming later. Breeding for disease resistance with the taro is hampered by the failure of the taro plant to set seed under field conditions. Possible methods of overcoming this barrier are being studied by the Department of Agronomy. (Parris, Bowers)

Diseases of the Taro Leaf Usually Not Serious

There are two fungus diseases which cause appreciable leaf necrosis of taro in Hawaii. *Phytophthora colocasiae* Rac. may have some economic significance from the standpoint of the soft rot of the corm, but owing to the speed of growth of the taro plant, whereby a new leaf is produced every seven to ten days, spraying or dusting, in the opinion of growers, is not economically possible. On upland taro, *Phyllosticta colocasiophila*, Weedon occasionally causes much leaf destruction. Here again, spraying or dusting does not seem to be worth the cost of application except in cases of severe attack, which are rare. Both fungi are favored in their spread and infection by cool, moist weather accompanied by high winds. Should it be found necessary to spray or dust irrigated taro, special machinery will have to be devised. A species of Macrosporium causes small yellowed spots on both sides of taro leaves, but is of no economic significance. (Parris)

DISEASES AND INSECT PESTS OF TOMATO

The islands of Kauai and Oahu have been carefully surveyed for diseases of tomato. The principal fungus diseases causing losses in the Territory are early blight (*Alternaria solani*) and Phoma rot (*Phoma destructiva*). Wilt (*Fusarium* sp.) is sometimes severe. Mosaic is prevalent everywhere often causing light set of fruit. Blossom end rot is the principal physiological disorder. Insect pests are abundant on tomatoes, the fruitworm (*Chloridea obsoleta*) and the melon fly causing much damage. Infestation by nematodes occasionally is severe. Spray programs in cooperation with variety testing investigations by the Departments of Agronomy and Horticulture are

planned. The possible rotation of tomatoes with taro is under consideration. (Parris)

DISEASES AND INSECT PESTS OF TRUCK CROPS

Most of the diseases and insect pests found are common on the mainland with control measures already well known. The prevalence of disease in Hawaii is due mainly to failure of proper application of fungicides and insecticides at the appropriate time by the farmer. Demonstration experiments with a number of individual farmers seem to be the answer to this problem. Surveys of the disease and insect problems of the islands of Oahu and Kauai have been completed, and similar surveys of the other islands are planned.

Following is a list of fungus diseases and insect pests which were found on the various agricultural crops in Hawaii. (Parris)

Miscellaneous Fungus Diseases and Insect Pest

Asparagus. Leaf spot (*Cerospora asparagi*); red spider (*Tetranychus telarius*).

Avocado (*Persea americana*). Fruit rot (*Gloeosporium* sp.)

Begonia (*Begonia semperflorens*). Nematodes.

Banana (*Musa cavendishi*). Wilt (*Fusarium oxysporum cubense*).

Beet (*Beta vulgaris*). Leaf spot (*Cercospora beticola*).

Broccoli (*Brassica oleracea* var. *botrytis*). Leaf spot (*Alternaria brassicae*).

Beans (*Phaseolis vulgaris*). Mosaic; Leaf spot (*Phoma subcircinata*); Leaf spot (*Phytomonas phaseoli*); Anthracnose (*Colletatrichum lindemuthianun*); Mexican bean beetle (*Epilachna corrupta*).

Chrysanthemum. Leaf spot (*Puccinia chrysanthemi*).

Canavalia (cult.). Leaf spot (*Septoria canavaliae*).

Cantaloupe (*Cucumis melo*). Anthracnose (*Colletotrichum lindemuthianum*); Melon worm (*Diaphania nitidalis*).

Cabbage (*Brassica oleracea* var. *capitata*). Leaf spots (*Phoma lingam*, *Bacterium campestre*, and *Alternaria brassicae*); Web worm (*Hellula undalis*).

Cucumber (*Cucumis sativus*). Mosaic; Mildew (*Pseudoplasmopara cubensis*); Melon worm (*Diaphania nitidalis*).

Carrots (*Daucus carota* var. *sativa*). Leaf spot (*Cercospora apii carotae*); Root rot (*Sclerotium rolfsii*).

Cassava (*Manihot utillissima*). Leaf spot (*Cercospora* sp.).

Celery (*Apium graveolens* var. *dulce*). Leaf spot (*Septoria apii petroselini*); Apids (*Aphis* sp.).

Corn (*Zea mays*). Mosaic; Corn ear worm (*Heliothis obsoleta*).

Daikon (*Raphanus* sp.). Leaf spot (*Cercospora* sp.).

Egg-plant (*Solanum Melongena*). Leaf spots (*Cercospora melongae* and *Septoria lycopersici*); Wilt (*Fusarium* sp.).

Lily (*Lilium longiflorum*). Mosaic.

Lettuce (*Lactuca sativa*). Leaf spot (*Septoria lactucae*); Heart rot (*Bacterium vitians*).

Lupine (*Lupinus hirsutus*). Wilt (*Fusarium* sp. and Nematodes).

Macadamia (*Macadamia ternfolia*). Fruit spot (*Gloeosporium* sp.).

Mango (*Mangifera* sp.). Dieback (*Botryosphaeria ribis*).

Mustard Cabbage (*Brassica nigra*). White rust (*Albugo candida*).

Onion (*Allium cepa* and *Allium porrum*). Leaf spot (*Macrosporium* sp.); Thrips (*Thrips tabaci*).

Para Grass (*Pancium purpurascens*). Leaf spot (*Helminthosporium* sp.).

Potato (*Solanum tuberosum*). Tuber rot (*Fusarium* sp.); Late blight (*Phytophthora infestans*); Early blight (*Alternaria solani*); Wilt (*Fusarium oxysporum*); Mosaic; Rhizoctonosis (*Rhizoctonia solani*); Scab (*Actinomyces scabies*).

Pumpkin (*Cucurbita Popo*). Mosaic; Mildew (*Pseudoplasmopara cubensis*).

Pea (*Vicia faba*). Mosaic; Leaf spot (*Phyllosticta* sp).

Pepper (*Capsicum frutescens*). Leaf spot and fruit blight (*Gloeosporium* sp.); Leaf spot (*Bacterium vesicatorium*); Red spider (*Tetranychus* sp.).

Peanut (*Arachis hypogea*). Leaf spot (*Cercospora personata*).

Rice (*Oryza sativa*). Blast (*Piricularia oryzae*).
Roselle (*Hibiscus sabdariffa*). Root disease (*Fusarium radicicola*).
Radish (*Raphanus sativus*). White rust (*Albugo candida*); Web worm (*Hellula undalis*).
Sorghum (*Holcus* sp.). Smut (*Sphacelotheca sorghi*); (*Holcus halepensis*) Rust (*Puccinia purpurea*).
Arrowhead (*Sagittaria sagittifolia*). Leaf spot (*Pestalozzia* sp.).
Spinach (*Spinacia oleracea*). Blight (*Virus*).
Strawberry (*Fragaria* sp.). Leaf spot (*Mycosphaerella fragariae*).
Watermelon (*Cucumis Melo*). Anthracnose (*Colletotrichum lagenarium*); Mosaic; Mildew (*Pseudoplasmopara cubensis*).
Zanthium. Rust (*Puccinia zanthii*).

CHEMISTRY AND SOILS

FERTILIZER EXPERIMENTS WITH TRUCK CROPS

Potato

The acreage of early potatoes grown in Hawaii during the winter is expanding rapidly each year. During the past season a total of nine field experiments was completed. This includes six large-scale experiments of 120 plots each installed on sugar plantations. In previous experiments on pineapple lands potatoes had, in nearly all instances, shown a very marked response to phosphates, a moderate response to nitrogen, and no response to potash. The present experiments on sugar-cane lands showed the response of potatoes to fertilizer to be quite variable, but in general, showed much less response to fertilizer, particularly phosphorus, than similar experiments on pineapple lands.—(Fig. 1)

In the current year's experiments, nitrogen, as ammonium sulphate, in excess of 90 pounds per acre caused a depression in yields. This was in no case due to excessive topgrowth but rather appeared to result from "burning" during early stages of the growth. This phenomenon emphasizes the need of fertilizer-placement studies. Such studies elsewhere with potatoes

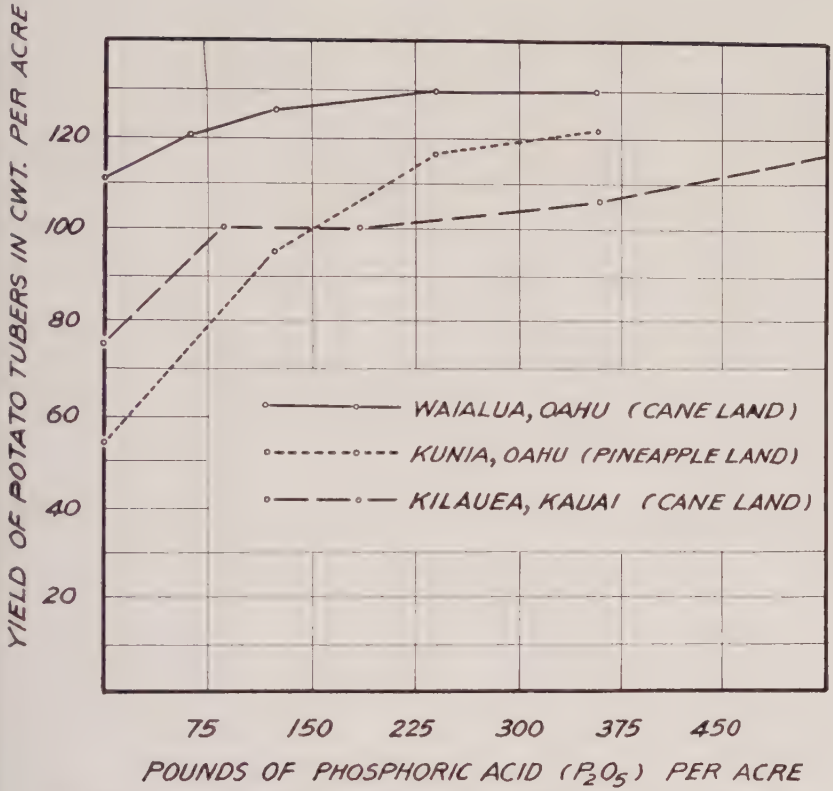

Figure 1.—Yield responses of potatoes to phosphate fertilization, constant and ample amounts of nitrogen and potash being applied in all treatments.

and other crops have emphasized the need of correct placement of fertilizer. The problem of increasing yields would seem to be one, in most instances, of increasing the amount of topgrowth and prolonging the growth period. In spite of very heavy applications of nitrogen fertilizer, there has been no instance in which the topgrowth has appeared excessive.

Study of the absorption of fertilizer by the potato plant, the fertilizer residues remaining in the zone of application, and the extent of leaching of the applied fertilizer into the subsoil was begun. A number of individual potato hills was harvested from the several treatments in three field experiments. Corresponding surface (0 to 6 inches) and subsoil (6 to 12 inches) samples of soil were taken from each hill harvested. The surface sample thus taken contained all fertilizer

still remaining in the zone of application. Analyses of the soil samples for soluble nitrates and ammonia, available phosphorus and potash, showed considerable amounts of the fertilizer still available and in the zone of application with little increase in available fertilizer in the 6th to 12th layer. These data, although of a preliminary nature, show the need of further studies on placement of fertilizer.

Other Truck Crops

An experiment in the Volcano District comparing the efficacy of organic and inorganic fertilizers for cabbage was continued through the fourth crop. Results indicate that organics, particularly fish scrap, are superior to an all-mineral fertilizer of similar plant food content. It is not yet proved that the superiority is sufficient to offset greater cost of organic fertilizer.

Small-sized cooperative experiments with the Agricultural Extension Division and various growers have been conducted on watermelon, asparagus, rice, and sweet potatoes. While such experiments are not adapted to measurement of small differences, they are effective where large response to fertilizer is found and they furnish a basis for a general survey of soil fertility of the many soil types in the Islands. (Ripperton, Edwards)

SOIL INVESTIGATIONS

Correlation of Results of Field Experiments with Laboratory and Greenhouse Tests

In connection with the various field experiments, correlating Mitscherlich pot tests, as well as numerous physical and chemical tests, are run on soils. These latter include moisture equivalent, pH, oxidation-reduction potential, organic matter, total nitrogen, water soluble nitrates, ammonia nitrogen, available phosphorus, and replaceable potash. In addition, so-called rapid chemical tests are being run on all soils. With the multiplicity of soil types and crops with which the Station must deal, laboratory and pot methods are not as yet to be considered a safe criteria of fertilizer needs unless substantiated by actual field experiments. (Edwards, Ripperton, Watanabe)

Moisture Surface Force Curves

Three methods of rapidly locating the moisture content-surface force curve for local soils as an indirect measure of permanent wilting percentage, have been explored. One of these developed locally and involving the continuous slow agitations of the sample in atmospheres of specified relative humidities has been abandoned because of practical difficulties although acceptable results have been obtained.

In common with other stations, local work indicates that the use of desiccators carrying sulphuric acid of specified densities permits the rapid and accurate location of the surface force curve along its drier arm, while the freezing point depression is a suitable means in the wetter region. In this sense the two procedures are nicely complimental. Complete curves for three soils of wide local occurrence have been drawn and a standardized procedure developed by which the approximate premanent wilting percentage of a soil or a soil separate may be expeditiously determined. From the limited number of soil samples studied, the permanent wilting of plants seems to occur when a pF on the Schofield de Costa[1] scale of about 4.0 has been reached. This is acceptably close to the value reported by these workers.

Present plans call for the use of this procedure for the indirect determination of the permanent wilting percentage of colloidal separates prepared in such ways that the effects of the more common constituents may be identified. The proposed procedure involves the elimination of iron oxide and the aluminosilicates from separate lots of the colloidal material. (Wadsworth)

Oxidation-Reduction Potential

Using the technique of Bradfield, Batjer and Oskamp[1] oxidation-reduction potentials (eH) were obtained for several hundred soils. This measurement is an index of aeration. The total range was from 534 to 824 millivolts for upland soils and 157 to 610 for submerged soils all corrected to a pH of 3.0.

[1]Schofield, R. H. and De Costa (1935). The determination of the pF at permanent wilting and moisture by the freezing point method. Proceedings of the Third International Soil Science Congress, Oxford, 1935.

[1]Bradfield, Richard, Batjer, L. P., and Oskamp, Joseph (1933). The Significance of the Oxidation-Reduction Potential in Evaluating Soils for Orchard Purposes.

In general the submerged soils having the higher eH value were the most productive for taro. Addition of powdered manganese dioxide to upland manganese free soils in amounts up to 10 per cent caused an increase in eH value from 715 to 780 millivolts. Chlorosis failed to develop in pot tests with rice using both types of soil even with additions of 10 per cent of manganese dioxide. Yields in the pot experiment were not influenced by the presence of manganese dioxide. (Magistad, Fukunaga)

COFFEE INVESTIGATIONS

Fertilizer Experiments Show Conclusive Results in Kona District of Hawaii

A statistical analysis was made of the results to date from fertilizer experiments in the Kainaliu, Holualoa and Kealakekua sections of Kona. The following conclusions may be drawn:

Kainaliu. When 6-year crop averages are considered, phosphoric acid in conjunction with nitrogen and potash, has not given statistically significant increases in yields over nitrogen and potash alone. Potash, along with nitrogen and phosphoric acid, gives approximately three times as great an average yield as does nitrogen and phosphoric acid without potash. Nitrogen alone, and nitrogen and phosphoric acid are poorer treatments than no fertilizer at all. By means of a moving average of the yields of each of the treatments, it has been shown that those treatments which receive potash have increased in producing power over the 6-year period, while those treatments not including potash have steadily decreased. By this same device, the beneficial effects of phosphoric acid when accompanied by nitrogen and potash, are shown to be increasing. (Fig. 2)

Holualoa. Results of a 2-year average show that the high potash treatments have given the highest yield.

Kealakekua. Differences in yield were statistically significant even at the end of the first crop, due to a much smaller experimental error than in the other experiments. This smaller error is due partly to the topping system of pruning which is

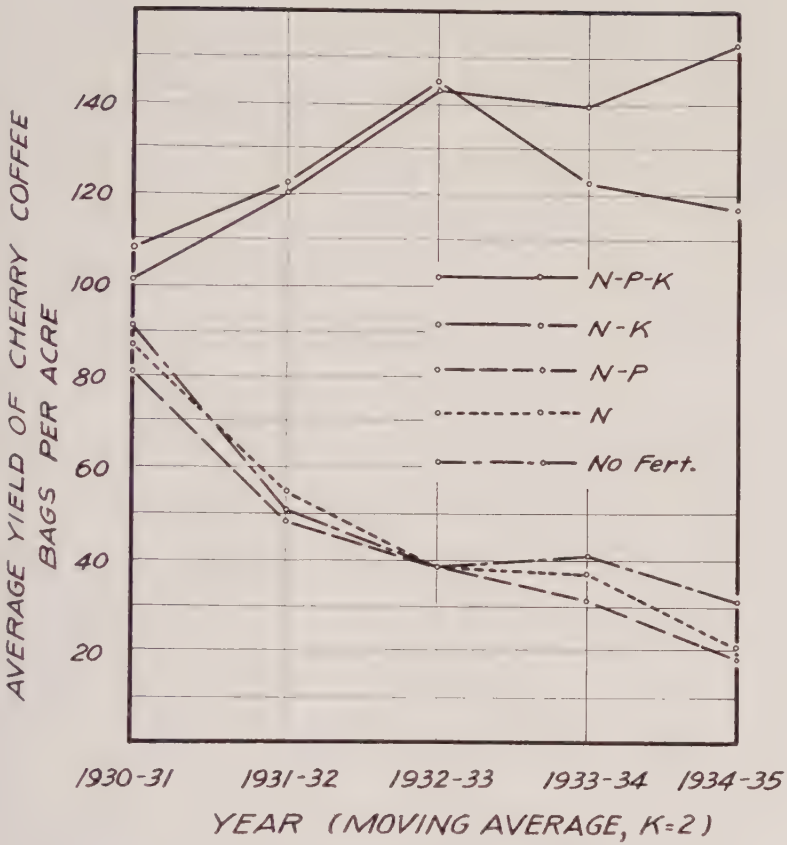

Figure 2.—Trend of yields of coffee at the Kainaliu Fertilizer Experiment, Kona, Hawaii.

employed and partly to the longer bearing season induced by the higher altitude. The results show that both nitrogen and potash have produced significant yield responses. (Ripperton, Edwards)

Dieback of Coffee Studied in New Experiment

The coffee die-back experiment, established in 1934 to study the effect of various methods of restricting the bearing surface in causing die-back was discontinued. Die-back was not appreciable in any of the treatments. Two of the pruning methods used appear feasible in commercial practice, first, complete removal of about one third of the primary laterals in the section of the vertical where the bearing surface is excessive and

second, restriction of bearing surface by single and double capping of the developing verticals.

A new experiment was laid out at a lower elevation where die-back has been severe during the past two or three years. The treatments are designed to show the effects of pruning, fertilizer formula, and increased organic matter upon the prevalence of die-back as follows.

(a) Pruning: A comparison of the usual pruning practice with one which restricts the bearing surface by capping and cutting out excess primary laterals. This comprises all of the best pruning methods developed in the previous experiment.

(b) Fertilizer formula: Comparison of 4 fertilizer formulas as follows: 8-8-8, 8-4-12, 4-8-12, 12-0-12.

(c) Coffee pulp augmented by commercial fertilizer to build the treatment up to the 8-4-12 level of fertilization.

There are 6 treatments replicated 6 times and arranged as a Latin-square. Each plot consists of 2 trees with ditches dug between plots to prevent crossing over of roots from one plot to another.

Currently low prices of coffee are forcing the growers to curtail fertilizer applications. This has emphasized the importance of adapting the fertilizer formula more closely to the economic returns, and formulas of the order of 8-5-13 are in demand over the older formulas of approximately 8-8-8. The use of coffee pulp as a partial substitute for mineral fertilizers is on the increase. Some farmers dry and grind the pulp at the end of the picking season and mix it with mineral fertilizer. Composting experiments with coffee pulp at the Kona Substation have demonstrated that a pile of pulp will remain for a year with practically no decomposition within the pile. Alternating parchment or other coarse dry material with layers of coffee pulp, permits aeration and effective decomposition in small piles. Such decomposition results in some loss of nitrogen and organic matter. It still remains an open question whether the labor required to prepare composts and dry the resultant materials could not be more profitably applied toward returning the undecomposed pulp to the field. In this

case, on decomposition the nitrogen is mostly retained by the soil. Many good farmers contend that decomposition of this pulp in the field has no deleterious effect on the coffee tree. (Ripperton, Edwards)

Chemical Changes in Coffee Cherry and Soils from Continuous Fertilizer Experiments

Samples of coffee cherry and soil are being taken annually from each treatment of each of the three continuous fertilizer experiments in Kona. A total of 17 samples of coffee cherry from these experiments was collected during the year. Each sample was subdivided into pulp and bean and analyzed for nitrogen, calcium, magnesium, phosphorus, potassium, and total ash.

Corresponding soil samples were analyzed for moisture equivalent, pH, total and available nitrogen, available phosphoric acid and potash, and eH (oxidation-reduction potential). Table 6 shows the striking differences found in the Kainaliu experiment at the end of the sixth crop.

Table 6—Changes in pH, eH and replaceable potash of the soil in the Kainaliu coffee fertilizer experiment resulting from 6 years of unbalanced fertilization.

Fertilizer Treatment	Yields of coffee cherry[1] per acre	pH	eH	Replaceable potash per cent
	Cwt.			
N-P-K	191.7	4.82	.970	.043
N-P	17.4	4.57	.677	.011
N-K	147.9	4.75	.931	.045
N	17.3	4.5	.691	.014
Check	31.7	5.7	.826	.011

[1]1935 crop.

The localized effect of fertilization is most striking and correlates directly with differences in yields. These soil samples were taken to a depth of 6 inches at the periphery of the tree where fertilizer is applied each year and hence do not represent the entire soil mass to a depth of 6 inches. The practice of applying the fertilizer on the surface, in the same location each year, and without any appreciable stirring of the soil tends to induce excessive root development with the resultant tendency to marked soil changes in this localized

area. The significance of these data with respect to the nutrition of the coffee plant or the quality of the coffee bean must depend on additional work.

A statistical analysis was made of the results of analyses of coffee cherry during the past two years. The chief conclusions are that potash fertilization causes a marked and significant increase in the potash content of pulp and bean. The effect of nitrogen fertilization upon the composition of the pulp is inconclusive, but it produces statistically significant increases of nitrogen in the bean. The percentage of phosphoric acid present in samples of pulp is affected but slightly by the presence of phosphate in the fertilizer applied, its percentage in the pulp being, in any case, low. In the case of the samples of bean, the response to phosphoric acid is not significant but is much larger than in the pulp samples. The percentage of this element in the bean is approximately three times that in the pulp.

The percentage of calcium in both pulp and bean shows a positive correlation with the percentage of potash while magnesium is an inverse function of the percentage of calcium, potash and of total yield. (Edwards, Ripperton, Watanabe)

MACADAMIA NUT INVESTIGATIONS

Hand Cracking and Grading Rough Shell Macadamia Nuts in Kona a Feasible Procedure

Special attention has been given the methods of handling the rough shell variety now being grown in the Kona District. This variety is generally regarded as inferior to the smooth shell variety, by the present trade, which has been developed by growers of the smooth shell variety. The Kona growers thus find it difficult to market their nuts. A cooperative project was carried on with the growers to determine the feasibility of curing, hand cracking, and grading the nut in Kona. The nut collections of the various growers were brought to Kailua weekly where they were husked, cured, hand cracked, and water graded to eliminate the culls. It has been found that macadamia nuts with a specific gravity greater than unity are of inferior quality. Throughout these various operations, the nuts of the different growers were kept separate, so that pay-

ment to the grower could be made on the basis of pounds of grade 1 nuts rather than on gross weight of nuts. A total of 1200 pounds of kernels were received in Honolulu, where they were dehydrated and stored for subsequent sale. Results of the season's work indicate that the hand cracking of the nuts at Kailua is feasible with the proper facilities for handling the nuts. The quality of nuts from the various growers varied from worthless to good quality. The poorest nuts required 30 pounds of unshelled nuts to produce one pound of grade 1 kernel, while the best required but 4.3 pounds. A characteristic of the rough shell variety is that of underfilling or of dropping off prematurely. This was well exemplified in Table 7 which shows the striking improvement in quality as the season progressed. The December shipment of all growers averaged but 28 per cent grade 1 kernels, while the final shipment made five months later average 85 per cent. (Ripperton, Moltzau)

Table 7—Progressive Changes in the Quality of Kona Rough Shell Macadamia Nuts throughout the bearing season.

Date received	Proportion of kernel in nut	Proportion of Grade 1 kernels	Pounds nut required to give one pound of Grade 1 kernels
	Per cent	Per cent	
12- -35	21.69	27.88	16.54
2-17-36	No data available	44.48	
3-7-36	26.44	53.37	7.09
3-17-36	25.5	70.80	5.54
3-26-36	24.55	65.49	6.22
5-7-36	23.53	79.94	5.32
5-25-36	27.03	84.91	4.35

Considerable Latitude in Curing Conditions Possible Without Affecting Quality of Nuts

The curing and storage of macadamia nuts is still on a small lot basis with little actual data available. During the curing period the freshly gathered nuts are husked, and slowly dried in shallow layers in trays with adequate air circulation for about three weeks or until the moisture content is 3 per cent. Variations of this procedure which were studied were storage of the unhusked nuts in sacks, air-drying before husking, sun-drying of husked nuts, drying of the husked nuts at elevated temperatures, drying the husked nuts in a specially

designed stack dryer in which conditions of temperature and humidity of the circulating air can be controlled, and the use of desiccants in the final stages of curing. Moisture, sugars, and oil content were determined at intervals and cooking tests were made to determine the effect on quality. Partial results indicate that with adequate circulation of air, considerable latitude is possible in handling the nuts during the curing period. The unhusked nuts held in sacks for one week had developed a distinct musty flavor. Sun-drying reduced the moisture content from 23 per cent to 2.8 per cent in one week's time and the quality of the cooked product appeared somewhat superior to nuts cured by the regular procedure. Where a hot, dry location is available, sun-drying may be a practicable method. For factory curing, the stack dryer appears to have important commercial possibilities in economy of space and hand labor and a more exact control of conditions of curing than is possible with the present tray method. (Ripperton, Moltzau)

THE STEROLS OF TROPICAL OILS

The studies described in the annual report of the Station for 1935 of the sterols of tropical oils, namely, avocado, kukui-nut, china-wood, chaulmoogra, and coconut were continued. Methods of obtaining oil supplies with high sterol content, of isolating satisfactory supplies of unsaponifiable portions of oils, of identifying sterols, and of establishing physical constants were investigated. Extensive studies were made on methods of purifying sterols obtained from various oils.

Suitable oil supplies. Investigations have shown that ordinary commercial grades of oils as secured on the market are low in sterol content, and hence make poor sources of sterols for chemical studies. The explanation lies in the fact that a large portion of the sterols present in the natural oils to the extent of only about one per cent is lost in the settling, decolorizing, filtering, and other purification processes to which the oil is subjected in commercial treatment. Oil supplies must be prepared either by hand or under personal supervision in order to insure the maximum yield of sterol fraction.

Isolation of unsaponifiable portion of oil. The detailed method used for isolating the sterols from the respective oils was described in a previous report[1] and has continued to serve as a satisfactory procedure from the standpoints of purity and yield of sterols. The following table shows yields of sterols.

Table 8—Yield of sterols from oils of different sources

Source of oil	Number of runs	Weight of oil	Unsaponifiable portion
		grams	per cent
Avocado	9	3650	1.583
Kukui-nut	5	1890	0.781
China-wood	3	1200	0.442
Chaulmoogra	8	3000	0.337
Coconut	4	1200	0.264

[1]Hawaii Agricultural Experiment Station Report, 1931 (1932) Bilger, L. N., Young, W. Y., and Robbins, R. C. Report of special avocado chemical investigations.

Identification of sterol fraction. The crude sterols from the various oils were subjected to qualitative tests in order to identify them as belonging to the large group of organic substances known as the "sterols" or "solid alcohols." The Whitby "A" color reaction gave definite positive results for all samples except china-wood oil, but the Whitby "B" color reaction strongly confirmed this doubtful case as well as all the others.

A recheck of the molecular weight of avocado sterol as determined by the lowering of the freezing point (375.2) was performed by the camphor-fusion method (364.4). Good agreement was secured for this one sterol, and the method will be used on the other sterols when they have been purified sufficiently. Melting points of the crude fractions were determined in order to predict the amount of purification needed. The results were low and not sharp, indicating the presence of impurities which must be removed by purification processes.

Purification of Sterol Fractions. The method of purification previously used on the avocado sterol was to crystallize repeatedly from hot aldehyde-free alcohol. High, sharp, melting-points were secured, indicating practically pure samples, but the method was found to be very wasteful of material. The low yields of other sterols rendered this method prohibitive

and therefore studies were initiated to determine how the bulk of sterol could be separated from the accompanying impurities in one operation.

Chilled petroleum ether was found to dissolve pigment impurities very well, but only small quantities of solvent with relatively large amounts of crystalline material could be used advantageously. The preparation of sterol digitonides and treatment of the digitonides with inert solvents, including xylene and pyridene, were investigated. Boiling with xylene resulted in incomplete splitting and partial decomposition. The results with pyridene were more promising and its use is under investigation at the present time. In order to separate singly and doubly unsaturated sterols, di-brom and tetra-brom acetates were prepared by acetylation, bromination, and reduction. Poor yields were obtained but the procedures are under continued study. When satisfactory yields of pure sterols have been prepared from the five oils, a study of chemical composition, constitution, and classification of the sterols will be made. (L. N. Bilger)

IODINE CONTENT OF HAWAIIAN SOILS AND ROCKS

The determination of the iodine content of Hawaiian waters, fruits, vegetables, marine foods, and eggs, described in previous reports was extended to rocks and soils and an investigation of poultry and meats was begun.

Thirty-one soils and six rocks were studied. In order to make the investigation uniform over the islands, soils and rocks were secured from the islands of Hawaii, Maui, Kauai and Oahu. Soil specimens were taken from dry and wet fields, from fertilized and unfertilized areas, from flower beds and from mountain slopes. In some cases surface scrapings were used and in others samples were secured with a soil augur. In general, rock samples were taken from unweathered material. Coral rock was obtained from an uplifted reef. Representative data are given in Table 9.

Table 9—Iodine content of typical soils of the Hawaiian Islands.

Source	Altitude	Rainfall annual	pH	Iodine
	Feet	Inches		PPM.
Maui—Hawaiian Commercial & Sugar Co.	80	10	7.30	20.4
do	100	12	8.05	11.0
do	150	7	7.50	30.9
do			8.31	27.0
Maui—Wailuku	150		7.65	23.0
do	200	35	7.20	23.8
do	350		7.20	31.0
do			6.62	13.8
Maui—Lahaina	700	50	6.19	29.7
do		12	7.57	8.6
Maui—Olawalu		2	7.36	15.5
Hawaii—Pepeekeo	800	120	5.97	75.2
do	1500	160	5.70	98.3
Hawaii—Paauilo	750	80	6.19	87.5
Hawaii—Kukaiau	1700	88	5.67	111.0

Table 10 gives the iodine content of typical rocks of Hawaii.

Table 10—Iodine content of typical rocks of the Hawaiian Islands.

Source	Type of Rock	Iodine (PPM.)
Palolo Quarry	Andesite	5.39
Koko Head	Conglomerate of ash and gravel	3.52
	Partially weathered limonite	17.9
Moiliili Quarry	Basalt	4.88
Makiki Heights	Volcanic cinders	3.06
Ewa	Coral rock	6.83

The number of samples of soils and rocks thus far are too limited to permit sound correlations of the other factors with the iodine content. (E. M. Bilger)

TARO PROCESSING

Semi-commercial Scale Processing Plant and Control Laboratory Equipped

The plant equipment includes: *power*—steam boiler and oil burner, *cooking*—steam jacketed kettle and pressure retort, *grinding*—regulation taro grinder for preparing paiai[1] from cooked taro, *mixing*—regulation poi mixer for preparing poi from paiai, *drying*—double drum type dryer for liquid products and cabinet type dryer for chips and flakes, *pulverizing*—hammermill type for pulverizing dried products, *sifting*—gyrotype for sifting flours and *baking*—cabinet oven for baking and roasting. (Plate 7) The chemical laboratory is

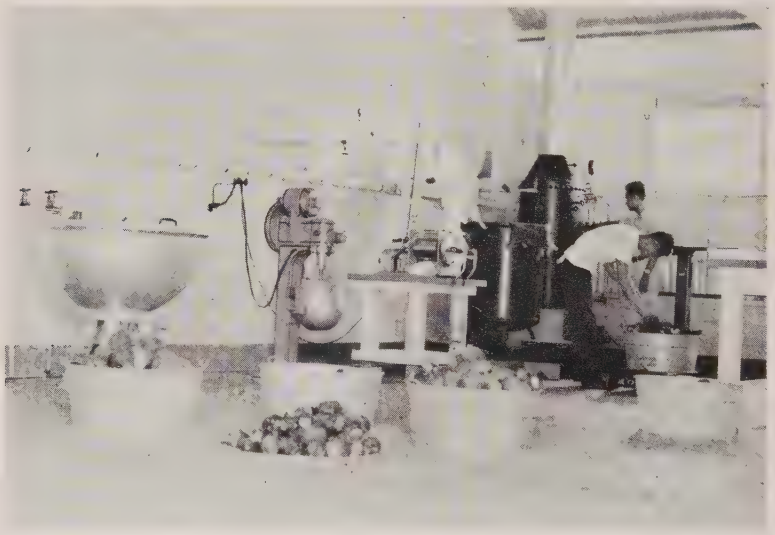

Plate 7.—View of Taro Processing Laboratory. From left to right are steam jacketed kettle, mixer, experimental size drum dryer, pressure cooker and upright steam boiler. Other equipment in the plant includes hammer mill pulverizer, gyro sifter, cabinet oven and poi grinder.

equipped for routine analysis, special chemical studies of processing problems, and development of formulas of prepared foods.

[1]"Paiai" is the ground cooked taro corm with the addition of little or no water. Poi is prepared by diluting paiai to not less than 30 per cent solids and allowing it to ferment.

Step by Step Study of Drying Process Necessary

Production of dried taro flour in the past has been fraught with numerous technical difficulties. The product lacked uniformity, often contained the so-called "taro itch" and was costly to manufacture. In the present investigation each step in the procedure was studied and a number of important new processes were developed.

Cooking of taro corms. It was found necessary to cook the taro corms preliminary to drying in order to eliminate the taro "itch." This confirms the experience of previous attempts. Pressure cooking is much superior to steaming which is the ordinary procedure. Taro corms may be cooked completely in one hour at fifteen pounds steam pressure as compared with three to four hours at atmospheric pressure.

Type of dryer. 1. Tray drying—Sliced cooked taro can be dried satisfactorily in a recirculating type tray cabinet. The time required varies from 3 to 12 hours, depending upon the temperature and humidity. The cost is 15 to 27 cents per 100 pounds of dry material calculated on a fuel oil basis.

2. Drum drying—Poi or diluted paiai may be dried by means of a double drum drier to form a product of the beverage powder type. The cost of producing the dried product is estimated at 38 cents per 100 pounds.

3. Spray drying — Drying poi or diluted paiai in a spray dryer similar to that used for drying milk and other such products cost 58 cents per 100 pounds of dry material on the basis of an experimental run made by a mainland firm.

Methods of Drying Determine Type of Taro Flour

Of the three methods of drying described above it has been found that flour produced by grinding and sieving the tray-dried product seems to be most satisfactory for use in baked foods due to its granular texture. Average yields of 25 per cent flour have been obtained on the raw taro basis. The spray-dried flour is very fine mesh and not so satisfactory as coarser mesh flour. The drum-dried flour is flaky in texture. (Ley, Payne)

MANY USES OF DRIED TARO PRODUCTS DEVELOPED

Cereal products. Prepared pancake and waffle flours have been compounded utilizing taro flour in amounts up to 40 per cent of the total cereal content. The taste, consistency, and eating quality of foods prepared from these flours are excellent. Cereals can be prepared from dried, cooked taro by roasting the ground or shredded product at temperatures from 250 to 350° F. These cereals do not become gelatinous or lose the discreet character of the individual particles upon addition of milk and water. Beverage powders containg taro flour, salt, sugar, and flavoring materials have proved satisfactory in the preparation of beverage foods.

Baking studies. A series of baking tests show that taro flour can be used with good results in practically all types of baked goods. The percentage of taro flour which will not materially alter the character of the finished product varies with the type of baked product from 10 to 60 per cent. The lower figure holds for products which depend upon aeration for their quality. The higher figure applies to products such as cookies.

Certain products in which taro flour has been incorporated may be regarded as superior to the corresponding wheat products. This applies especially to layer cakes, cup cakes, doughnuts, and waffles. Bread containg 20 per cent of taro flour is also of excellent quality. An increased absorption of water of 2 to 5 per cent is found, and less shortening is required than with wheat flour alone.

The following table gives the maximum percentage taro flour thus far found desirable in various baked goods:

Table 11—Proportion of taro flour which can be incorporated into different types of baked goods.

Product	Per cent taro flour	
Dropped cookies	50	
Rolled cookies	75	
Muffins	25	
Biscuits	30	
Pastry	40	
Layer cake	20	
Cup cake	25	
Doughnuts	40	
Rolls	20	
Bread	20	(Ley)

Taro Varieties Show Differences in Processing Characteristics

A preliminary study of twenty-five taro varieties with regard to processing characteristics has been completed. The data in Table 12 are characteristic for six promising varieties.

Table 12—Chemical and physical differences in taro varieties.

Variety	Lab. No.	Type	Moisture in Paiai	Yield of flour	Acidity of Paiai			Flour color
					One Day	Two Days	Three Days	
			Pct.	Pct.	Pct.	Pct.	Pct.	
Mana ulu	2924	Upland	68.8	27.5	.28	.39	.39	Yellow
Ele-ele Naioea	.....	"	60.0	27.9	.36	.43	.43	Light chocolate
Palaii	2849	"	63.1	30.9	.42	.50	.49	Tan
Piko kea	2838	Wetland	66.3	29.5	.46	.58	.47	Light
Hae Hae	.....	"	59.6	30.2	.39	.41	.42	Gray-tan
Pii Alii	.....	"	63.4	27.55	.27	.55	.65	Reddish gray

Complete chemical analysis of flour prepared from four promising taro varieties, two dryland and two wetland, is under way. This includes complete mineral analysis.

Taro "Itch" Due to Calcium Oxalate Raphides

A study of taro "itch" has shown that the calcium oxalate raphides responsible for the "itch" are present in extremely small numbers in the taro corm. Attempts at developing a chemical method form ascertaining the degree of "itch" have not been successful.

Fermentation Studies of Dried Taro Products

Taro flour mixed with water to the consistency of paiai does not undergo normal fermentation. Attempts to inoculate the flour paiai with dried (110° F.) pai flour failed, indicating that drying destroys the organisms necessary for normal fermentation. Innoculation with four-day-old poi produced rapid fermentation, but the resulting poi was not so satisfactory in taste as fresh poi.

Pigments of the Taro Corm

The yellow taro variety Mana ulu contains a carotinoid pigment at a concentration of 13 parts per million. The red pigment of the Pii Alii variety is an alcohol soluble indicator, and is valuable in indicating the condition of the corm. A healthy

corm is acidic and red; a diseased portion is basic and green to black in color. (Payne, Akau)

FOODS AND NUTRITION

Papaya is One of Our Most Nutritious Fruits

Experiments in the Nutrition laboratory have shown that papaya is one of Hawaii's most nutritious fruits. It is a good source of sugars, calcium, and basic ash, comparing favorably with the orange in these respects.

Biological tests with laboratory animals show it to be an excellent source of vitamins A and C, a poor source of vitamin B, and a fair source of vitamin G. Using chemical methods, it was found that vitamin C (ascorbic acid) content of papaya increases with ripeness and that the average ascorbic acid content of 70 milligrams per 100 grams of ripe edible fruit is slightly greater than the average for oranges.

Analyses proved that papaya grown near the sea may have four times as much chlorine (salt) as those grown 300 feet and more above sea level, but even the highest figures do not exceed those for some other common foods. (Miller, Robbins)

The Vitamins and Minerals of Taro

Japanese taro, a variety of *Colocasia esculenta* producing small corms, is much relished by the Japanese of Hawaii though it is used in smaller quantities than white potatoes. It seemed desirable to know the antiscorbutic value of the Japanese taro, as previously published experiments of the so-called wetland or Chinese taro indicated that cooked taro is a rather poor source of vitamin C.

Biological tests, using 18 standard guinea pigs, indicate that Japanese taro has a low but definite antiscorbutic value somewhat less than that of white potatoes. In our experiment, 15 grams of cooked Japanese taro daily did not protect the guinea pigs from gross scurvy to any greater degree than did 10 grams. The experiments with 10 gram supplements of taro were carried out in the winter and those with 15 gram supplements in the spring. It seems possible that there is a seasonal variation in the taro, or that the taro purchased and fed in the spring at the 15 gram level had been harvested in the winter

and that it had lost some of its antiscorbutic potency during storage. Preliminary feeding experiments indicate that Japanese taro is a good source of vitamins B and G, but that it has little or no vitamin A.

It is coming to be recognized that the diet of many people in Hawaii contains inadequate amounts of calcium or lime largely because of the extensive use of polished rice. Those interested in improving this condition have advocated the substitution of a number of other foods for polished rice. Among these foods, taro and taro products have been strongly recommended.

Chemical analyses show taro to contain much more calcium than does rice; in fact, it contains sufficient total calcium to supply a large portion of the human daily needs if used in rather large quantities. However, the calcium of all foods does not appear to be equally well utilized, and it seemed important to know the extent to which the calcium of taro is absorbed and used for human nutrition. With this in view, experiments with rats and with humans were undertaken. Such experiments entail analysis of all articles of the diet, of the excreta, and, in the rat experiments, of the carcasses as well. The actual feeding experiments have been completed and a beginning made on the chemical analyses. Preliminary results for a few of the rats indicate that the calcium of taro is well utilized. (Potgieter, Miller, Takase)

Vegetables Absorb Vitamin B from Rice Bran when Bran-Salt-Pickled

The Japanese coming to Hawaii brought with them many of their food customs. One which has persisted is the preservation of vegetables by pickling them in salt with or without such accessory substances as rice water, sake residue, miso, kogi (fermented rice), and rice bran. In order to learn the effect of such procedures on the nutritive value of foods, the nutrition laboratory has carried out a number of experiments, the results of which are summarized below.

Pickling Chinese cabbage in salt destroys 50 per cent of the original vitamin B whereas pickling in a paste of salt and rice bran increases the vitamin B to almost four times the original value.

When *daikon* is pickled in a paste of salt and rice bran it is called *takuan* and in this form or in the fresh state is utilized when available by the majority of Japanese families for every meal. *Daikon* is a very poor source of vitamin B, whereas the bran-salt-pickled product, *takuan*, is a very good source, containing when freshly made seven times as much vitamin B as *daikon*. The growth response of groups of rats fed these two foods as the sole source of vitamin B are illustrated in Figure

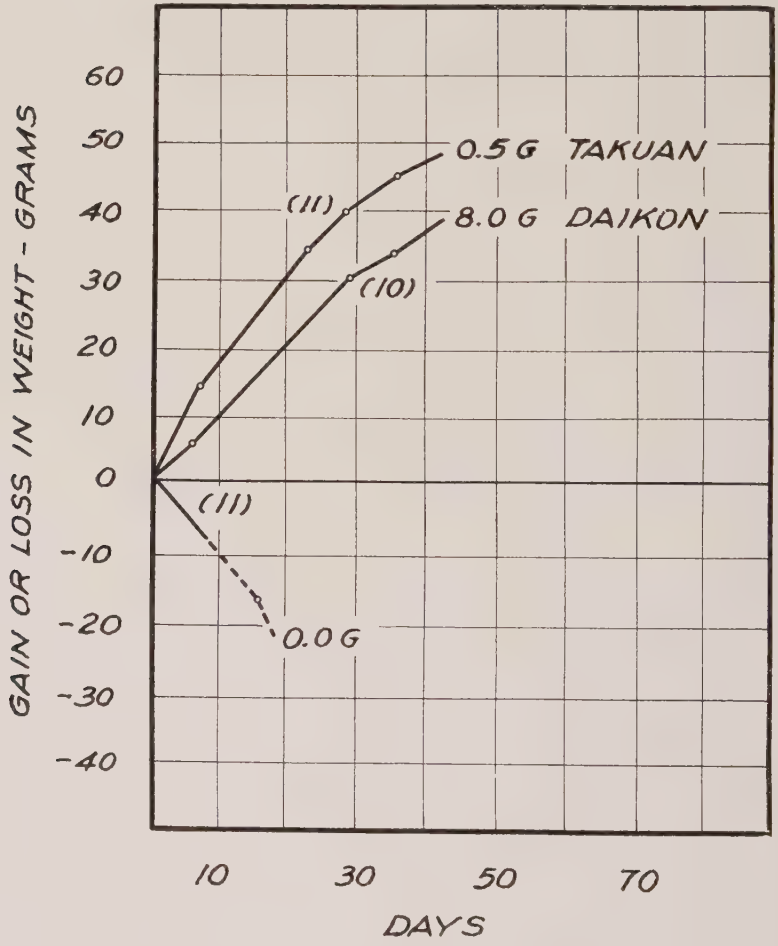

Figure 3.—Average growth curves of rats fed daikon and takuan (daikon pickled in salt and rice bran) as the only supplements to a vitamin B free diet. (Figures in parenthesis indicate the number of rats fed.)

3. The rats fed *daikon* received 8.0 grams per day and the rats fed *takuan* only 0.5 grams per day (equivalent to 1.4 grams of fresh).

Fresh eggplant is a good source of vitamin B and as a result of the bran-salt-pickling process has its vitamin B increased only about 1½ times the original value. The pickling process probably has less effect because the relatively impervious surface of the fruit, which is always pickled whole with the stem end intact, does not readily permit permeation of the water soluble vitamin.

Chemical analyses of Chinese cabbage, eggplant, and *daikon* indicate that the proportion of phosphorus as well as the salt is increased as a result of the bran-salt-pickling process.

In contrast with pickling in salt alone which decreases the original quantity of vitamin B, the general use of rice bran for pickling vegetables as a method of preservation is a practice much to be commended. It utilizes a product of high nutritive value, rice bran, otherwise little used for human consumption, and results in a product that has a greater vitamin B content than does the original vegetable. The consumption of such bran-salt-pickled products is of especial importance in the Japanese diet where the intake of vitamin B is likely to be low. Table 13 shows the chemical composition of *daikon* and *takuan* from various sources. (Miller, Robbins)

Table 13—Composition of fresh and bran-salt-pickled vegetables.

Material	Moisture	Protein (Nx6.25)	Ether Extract	Crude Fiber	Total Ash	Carbohydrate (by diff.)	Calcium (Ca)	Phosphorus (P)	Iron (Fe)	Sodium Chloride (NaCl)
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Daikon No. 14	94.6	0.3	0.1	0.6	0.77	3.6	O 031	0.036	0.00026	0.11
Takuan No. 14[1]	80.2	1.7	.2	1.8	8.29	7.8	.054	.268	.00078	6.08
Daikon No. 15	94.9				0.72		.025	.013	.00043	
Takuan No. 15[1]	80.5				7.53		.046	.275	.00132	5.55
Takuan, commercial[2]	85.8	1.3	.1	1.0	7.82	4.0	.064	.080	.00050	6.55
Eggplant										
Fresh	92.6	1.1	.2	0.8	0.49	4.8	.010	.026	.00033	0.15
Bran-salt-pickled	87.3	1.5	.1	1.1	4.34	5.7	.012	.052	.00040	4.08
Chinese Cabbage										
Fresh	94.8	1.2	.2	0.5	0.95	2.3	.096	.039		0.12
Salt-pickled	90.5	1.9	.3	.9	3.96	2.5	.094	.040		3.17
Bran-salt-pickled	88.6	2.0	.2	1.0	2.88	5.3	.159	.141	.00366	1.86

[1]Prepared from fresh daikon in the nutrition laboratory.
[2]Imported from Japan.

THE OLD HAWAIIANS NEEDED NO COD LIVER OIL; THEY ATE OPIHI

One of the most important factors contributing to the fine physical development of the ancient Hawaiians was their food. Some previous studies of the nutritive value of their vegetable foods have been made and they are being continued in the

Plate 8.—The opihi (Helcioniscus exaratus and H. argentatus) a shellfish in Hawaii commonly used for food. 1. Dorsal view of shell. Left: H. exaratus. Right: H. argentatus. 2. Ventral surface showing muscular foot. 3. Opihi removed from shell, showing gonads. 4. Hepato-pancreas turned back to show sperm in male. 5. Hepato-pancreas turned back to show ova in female.

study of taro. The opihi, one of the most widely distributed and favorite shellfish of the ancient Hawaiians, is the first animal food to be studied in the Nutrition laboratory. (Plate 8)

Chemical analyses show the opihi, in the fresh state, to contain about one per cent of glycogen. It is a good source of protein, calcium, iron, and a poor source of fat and copper.

Because of the low copper content the opihi was found to have but slight effect in regenerating the hemoglobin of the blood of rats made severely anemic by an exclusively milk diet. When a supplement of copper salt was given with the opihi, hemoglobin regeneration was more rapid but reached normal values only after 6 to 8 weeks feeding. Opihi should be a good source of iron for hemoglobin building in humans as they secure ample quantities of copper from other sources.

Biological tests with laboratory animals have shown the opihi to be an excellent source of vitamins A and D and a poor source of B and G and to be devoid of C. A study of the gastro-intestinal contents of the opihi (through the courtesy of the Bishop Museum) shows the principal foods of the opihi to be forms of a species of minute blue-green algae and very young forms of two green algae. From these the opihi can make vitamin A and possibly vitamin D.

Undoubtedly the opihi is an excellent sea food, rich in protein, calcium, and iron. The quantity of vitamins A and D is equivalent to that of good cod liver oil when one considers the moisture content of the opihi. The results of the experiments with opihi suggest that additional studies of the shore and reef foods should be undertaken.

Marine Algae Have Food Value

To answer the many inquiries regarding the nutritive value of limu kohu, this marine alga has been analyzed and found to have the following percentage compositions:

Moisture, 90.8; protein (N x 6.25), 2.5; ether extract, 0.1; crude fiber, 1.0; carbohydrate (by difference), 3.4; total ash, 2.22; calcium, 0.089; phosphorus, 0.025; iron, 0.00593; and copper, 0.00045. (Miller, Robbins)

STUDIES OF THE BLOOD AND BLOOD FORMING ORGANS IN RECOVERY FROM NUTRITIONAL ANEMIA

Much valuable information regarding the changes that take place in the blood and blood-forming organs of the body in anemia and recovery from anemia may be obtained from experimental work with anemic rats. When normal adult rats are fed a diet that is considered complete in every respect, the feeding of additional copper and iron (daily quantities of 0.5 mg. iron and 0.08 to 1.9 mg. of copper) does not change the blood picture as judged by determination of the hemoglobin and white and red cell counts. Normal adult rats, when placed on an exclusively milk diet for a sufficiently long period (5 to 9 months) will develop anemia, though it is difficult to keep them in good condition and at the same time create as severe anemia (3.0 to 4.0 grams hemoglobin per 100 cc. of blood) as in the case of younger rats. After short periods of feeding iron and copper to adult anemic rats, an enlargement of the spleen was found to occur when the hemoglobin reached a value of from 6 to 8 grams, much the same as it did in the case of the younger animals. This increase occurs after 48 hours' recovery feeding.

Studies of the blood forming organs in anemia have been confined, heretofore, to the spleen. During the current year studies of the bone marrow and the liver were initiated. The hemoglobin and erythrocytes in the blood of splenectomized anemic rats increase as rapidly as they do in non-splenectomized rats when both groups are fed supplements of iron plus copper. Both groups of animals show a great increase in number of nucleated cells on the second and fifth day of recovery but the number of cells in the blood of the rats with spleens removed is much greater than in those with spleens intact. The difference in number of nucleated cells for the two groups is due to the liberation of immature erythrocytes into the blood stream in the splenectomized animals. This indicates that a temporary destruction of the equilibrium in the hemopoietic (blood forming) mechanism occurs as a result of splenectomy. Since the blood of splenectomized anemic animals returns to normal with respect to all blood elements on continued recovery, a new hemopoietic equilibrium is apparently established.

Study of the spleen and blood of young rats shows that both are in a relatively immature condition at the time of birth. Normal adult blood conditions are not established till the animals are from 35 to 50 days of age. The spleen at the time of birth is active in erythrocyte formation but this function is lost before the animals become 50 days old. The blood elements of young animals fed an anemia producing diet soon begin to decrease and an anemic condition is reached by the time the animals are 50 days of age. Erythrocyte formation in the spleen, though quantitatively decreased, persists longer in animals fed an anemic diet, than in animals fed a complete diet, and actually does not disappear till after the animals are 70 days of age. At that time the property of producing lymphocytes as well as that of producing erythrocytes has also been lost and the spleen of anemic animals may be said to have reached an exhaustive condition. (Hamre, Miller)

TRUCK CROP MARKETING

Two major activities were inaugurated under this project, namely, census of small farms and monthly truck crop estimate and experimental and educational activities looking toward the improvement of truck crop marketing conditions. The standardization of grades and packs and the education of growers as to their proper use was made a major activity of this portion of the program.

Census of Small Farming and Monthly Truck Crop Estimate

The census of small farming was completed and published June 25, 1936. It consists of a 24-page survey of the truck farming industry in the Territory. One or more trained agriculturists was assigned to each of the islands and a careful farm to farm canvass was made as to location, total acreage, and number of growers in each of the truck crop areas of the several islands. For each island and for the Territory as a whole, the acreage, estimated production, percentages consumed locally and shipped to Honolulu of 82 different varieties of vegetables and 31 fruits, are given.

With approximately the same personnel and technique, simplified monthly truck crop estimates have been and are being published, starting with the estimate for July 1936. These

estimates include 25 commodities. In addition to the acreage of each crop a beginning is being made in market forecasting to help the growers adjust their planting schedule to market demands.

The monthly truck crop estimate is being well received, printed in nearly its entirety in both English and Japanese language newspapers, and is being generally recognized as an important phase of the territorial truck crop industry. The original mailing list receiving this estimate included about 460 names, 48 per cent of them being growers. (Warner, Gast, Cady)

Vegetable Grading and Packing

After due consideration and study of the Honolulu wholesale market, it was decided to inaugurate the grading and packing standardization work by a demonstration with tomatoes on the island of Maui. In cooperation with growers' associations both in the field and on the Honolulu market, various chambers of commerce, the Federal-Territorial Food Products Inspection Service, and the Growers' Service Department of the Inter-Island Steam Navigation Company, this demonstration was inaugurated in March 1936.

Comparative prices over a period of several months have shown that the graded and standard packed tomato will return to the growers a premium of approximately 2 cents per pound more than the ungraded article shipped in second-hand kerosene cases as was the previous practice. Furthermore, island-grown tomatoes, when properly graded and packed, have usually sold on a parity price with the imported article.

It is felt that the standard lug pack of commodities is here to stay and that the kerosene case, which incidentally resulted in a 10 per cent loss upon arrival due to spoilage, is doomed as a tomato container. It is probable that some individuals or a growers' cooperative organization will take over this packing work on a commercial basis.

This project is now inaugurating experimental packs and packages using head cabbage, Chinese cabbage, cucumbers, and broccoli which are being shipped at this time of the year from the island of Hawaii to Honolulu.

The individual truck crop farms in the territory average very small in area. Comparatively few farms comprise over ten acres. A very large percentage of the work is done by hand. This naturally results in high costs of production. In addition to this situation, very few wholesalers on the Honolulu market are aggressive merchandisers. The combination of these factors represents the largest obstacles which our plans must overcome.

The census of small farming has shown a larger truck crop industry than has previously been thought. Table 14 summarizes the results of the census as to number of growers and total area planted to truck crops and fruits and nuts as of June 1936. These figures do not include the areas of such crops maintained by plantation laborers for their own use. (Warner, Gast, Cady)

Table 14—Summary of Truck Crop and Fruits and Nuts Industry in Hawaii as to location, area, and number of growers.

Island	Area Truck Crops	Area[1] Fruits and Nuts	Number of Growers
	acres	acres	
Hawaii	1,808	6,176	1,669
Maui	1,687	137	404
Oahu	3,059	2,332	1,412
Kauai	1,579	195	438
Molokai	784	5	168
Total	8,917	8,845	4,091

[1]Includes coffee.

ANIMAL HUSBANDRY

DAIRY

The dairy herd consists of 45 Holsteins and 14 Guernseys—all purebred registered animals. These serve the dual purpose of providing animals for research work and as a laboratory for students in dairy husbandry.

The herd is free from tuberculosis, and the contagious abortion test failed to show any positive reactors. However, some cows that gave a suspicious reaction are kept separate from the rest of the herd.

Experiments with Concentrate Mixtures

In two 12-week experiments, each with 6 cows, a concentrate mixture containing 44 per cent pineapple bran and 18

per cent cane molasses produced practically as much milk as another ration consisting entirely of non-local feeds, and resulted in an average saving of 30.4 per cent in the concentrate cost of milk production. These two experiments confirm the result of a similar experiment performed the previous year.

When a mixture containing 19 per cent sifted cane bagasse, 37 per cent cane molasses, 42 per cent oil cake meal, and 2 per cent minerals was fed to 4 cows in a 12-week experiment, milk production was only 83 per cent as high as when a ration consisting of 48 per cent wheat bran, 30 per cent barley, 20 per cent soy bean oil cake meal and 2 per cent minerals was fed. The former ration proved less palatable, consumption of same being only 87 per cent of the amount consumed of the latter ration.

In one 12-week experiment with 6 cows sesame oil cake meal and soy bean oil cake meal proved equally valuable as measured by milk production, body weight, and butter fat content of the milk. In this test these meals, which constituted 20 per cent of the total concentrate ration, were used as protein supplements in rations which were the same in all other respects. (Henke, Goo)

Molasses Poured Over Roughage Increases Milk Production

In one 12-week experiment with 6 cows the addition of 4 pounds of cane molasses poured over the roughage increased milk production by an average of approximately two pounds per cow per day. In the second 12-week test, also with 6 cows, an increase of one pound of milk per cow per day was noted when 4 pounds of cane molasses were poured over the roughage of each cow. Liveweight of the cows was greater in each case when molasses was added to the roughage, the increase being 9 pounds per cow in the first test and 21 pounds per cow in the second experiment. This indicates that pouring cane molasses over the roughage fed to dairy cows is a desirable and profitable practice in Hawaii. (Henke, Goo)

Sudan Grass Better than Napier Grass for Milk Production

Two previous experiments comparing Sudan and Napier grass for dairy cattle, had shown that the former produced a greater milk flow and a somewhat higher roughage consump-

tion. Two additional tests conducted during the year confirmed this conclusion. In these tests 6 cows were used, each test extending over a 12-week period. The cows, when fed Sudan grass, produced 8.7 per cent more milk, were 10 pounds heavier, and consumed 7.2 per cent more green roughage than when Napier grass was fed. The latter produced a slightly higher butterfat content in each experiment. Samples of the grasses were taken daily for chemical analysis. Table 15 gives the average composition of the two grasses fed in the two feeding trials. (Henke, Goo)

Table 15—Chemical Compostion of Sudan and Napier Grass Used in Feeding Trials

	Moisture	Chemical Composition of Forage[1]				
		Crude protein Nx6.25	Ether extract	Nitrogen free extract	Crude fiber	Total ash
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Sudan grass	82.5	7.26	1.21	43.83	36.80	10.90
Napier grass	76.2	5.15	1.18	39.37	38.60	15.70

Forage Yields on University Farm Compared

Some 12 acres planted to various forage grasses produced a total of 624 tons of green forage during the year, which was fed to the livestock kept on the University Farm,—largely to the dairy herd. One acre of Napier grass planted in July 1934 produced a total of 127.39 tons of green forage during the year ending June 30, 1936. Another planted in November 1934 produced 79.38 tons during the same year. An acre of alfalfa planted in December 1935 produced a green yield of 23.05 tons from January to June 1936.

SWINE

The swine herd consists of eight Berkshire and eight Tamworth breeding animals along with various smaller pigs. All swine not previously vaccinated are immunized against hog

[1]Oven dry basis.

cholera by the serum-virus treatment given about twice each year to such pigs as have been born since the last vaccination.

Pineapple Bran-Molasses Feeding Trials

In a series of 3 experiments averaging 49 days in length, 2 with 6 and 1 with 8 pigs, a fattening mixture consisting of 82 per cent locally produced feeds, 50 per cent pineapple bran, 20 per cent cane molasses, 12 per cent fish meal along with 18 per cent imported feeds, 14 per cent barley, 2 per cent linseed oil cake meal, and one per cent each of salt and bone meal, was compared with a ration which has been much used at the Hawaii Station consisting of 68 per cent barley, 20 per cent cane molasses, 8 per cent fish meal, 2 per cent linseed oil cake meal, and one per cent each of bone meal and salt. The average results of the three tests are given in Table 16.

Table 16—Camparative value of a pineapple bran-molasses ration and a barley-molasses ration in fattening swine.

	Pineapple bran-molasses ration lbs.	Barley-molasses ration lbs.
Average daily gain per pig	0.89	1.55
Concentrates consumed per pig per day	5.03	6.56
Pounds concentrates per pound gain	5.66	4.21
Feed cost per pound of gain	$0.057	$0.06

Under the conditions of these experiments the pineapple bran-molasses ration was worth only about 75 per cent as much as the barley-molasses ration for producing gains in swine but because of the lower cost of the former ration the cost of a pound of gain was about the same. The pineapple bran used in this test was first ground as pigs will not eat all of the coarser pineapple bran. If the pineapple bran-molasses ration is used it seems to give better results when the pigs weigh about 100 pounds or more for in one lot having about this weight an economy of one cent per pound of gain resulted as compared with the barley-molasses ration described above. In these cost comparisons barley was valued at $32.00 and pineapple bran at $14.00 per ton. (Henke, Goo)

Feeding Trials with Garbage

In two experiments conducted in the piggeries of cooperators, one of whom secured his garbage free but hauled it 14 miles by auto truck and an additional short distance by boat, and the other who purchased garbage at a rather high price, it was found that feeding the barley-molasses ration described above produced more economical gains than garbage feeding. More work needs to be done along these lines but results to date suggest that where garbage collection costs are unusually high or where garbage is purchased at a high cost, it is not always the most economical feed for fattening swine. (Henke)

Local Fish Meal, A Good Source of Protein for Swine

A fish meal made in a Honolulu fish cannery was compared with tankage in three experiments. Rations containing 68 pounds barley, 20 pounds cane molasses, 10 pounds tankage on fish meal, and one pound each of salt and bone meal were used. Average feed cost per pound of gain was 5.6 cents for fish meal versus 5.9 cents for tankage. (Henke, Goo)

Beef Cattle Feeding Trials

One extensive feeding trial with 71 steers has been started to determine the relative value of pigeon peas and improved grass pastures for fattening steers when used as the only feed, and when supplemented with cane molasses and additional protein. Two other trials, one a pasture trial on Koa haole (*Leucaena glauca*) with and without supplementary cane molasses, and the other a pen feeding trial in which cane molasses and pineapple bran in different proportions with protein supplements will be fed, have been definitely planned and will start in the near future.

In one cooperative feeding trial with 8 steers a concentrate mixture consisting of: 350 pounds pineapple bran, 300 pounds cane molasses, 200 pounds cane bagasse, 150 pounds soybean oil cake meal, and 10 pounds salt resulted in an average daily gain of 1.62 pounds per steer per day during the first 65 days of this trial. To produce a pound of gain, 11.17 pounds of the concentrate mixture in addition to 5.83 pounds of green cane tops were required. (Henke)

Plate 9.—Specially designed barn for making digestibility tests of Hawaiian feeds. Note the adjustable slat floor and the receptacles (left) for the feces. The heavy rubberized aprons shown attached to the box receptacles are held in place on the steer by a system of ropes and pulleys held taut by weights. The barn will house ten steers.

COEFFICIENT OF DIGESTIBILITY TRIALS

An experimental building for digestibility trials with a feed room, office and laboratory has been erected. (Plate 9) This building is provided with ten movable stalls of wood on top of a cement floor with the necessary facilities for collecting feces. Eight steers have been purchased for use in these digestion trials and the necessary equipment for the chemical work has been secured and installed.

Several trials with Napier grass have been conducted but results are not yet available. The coefficient of digestibility of various other tropical grasses and legumes and by-products of Hawaiian industries also will be determined. (Work)

POULTRY HUSBANDRY

Batteries for Laying and Breeding Hens

In a continuation of an investigation to determine the efficiency of hen batteries for laying and breeding stock, 60 Austrawhite pullets have been confined in a 60-hen compartment battery since November 1, 1935. Data gathered over a period of seven months indicate the mortality has been high

due to paralysis of the legs. Eleven of the 60 hens have been removed, all of which showed leg paralysis. It cost $1.17 to feed each hen for the first seven months of the experiment. An average production of 116.25 eggs per hen was obtained, valued at $3.005, and leaving a profit of $1.835 per hen above feed cost. The hens were fed commercial egg mash to which one per cent of refined cod-liver oil was added. This was supplemented with a fermented yeast mash. Previous work at this Station showed that when birds confined in laying batteries were fed a fermented yeast mash, normal body weight was maintained and approximately 30 more eggs per hen were laid than when no yeast was fed. (Bice)

Freshly Cut Alfalfa as Compared with Alfalfa Leaf and Blossom Meal in Poultry Rations

Comparison of newly cut alfalfa and alfalfa leaf and blossom meal in poultry rations indicates a greater variability in the intensity of yolk pigment from hens receiving fresh cut alfalfa. This difference was apparently brought about by the refusal of certain hens to consume alfalfa in sufficient quantities for the maintenance of yolk color of uniformly high intensity. Hens receiving alfalfa leaf and blossom meal in the mash produced eggs of uniform pigmentation of high intensity. Eggs produced by hens in the check pen were uniform in pigmentation but of very low intensity.

The following table shows the comparative value of the fresh and dried alfalfa:

Table 17—The comparative value of fresh alfalfa and alfala leaf and blossom meal in egg production.

Kind of Alfalfa Used	Intensity of Color of Egg Yolk	Mean Weight Per Dozen of Eggs	Ave. Cost of Feed Per Dozen of Eggs
		ounces	dollars
Check (no alfalfa)	1.8	19.85	0.12
Fresh Cut	2.8	20.6	0.14
Leaf and Blossom Meal	3.3	21.1	0.11

Mortality was greatest in the check group. Malnutritional roup, range paralysis (Neurolymphomatosis gallinarum), and

a general unthriftiness manifested themselves in this group. A lack of vitamin A was responsible for the appearance of malnutritional roup and for the general unthrifty appearance; whereas the paralysis, no doubt, crept in due to lack of vigor and resistance in the birds. At the completion of the year of lay, breeding records will be obtained from these pens to ascertain the value of green feed on the hatchability and on the livability of the chicks hatched. (Bice)

Humidity Control in Incubators Recommended

Eggs for this experiment were collected every three hours and immediately placed in an egg cooler at a temperature of 58° F. The relative humidity was increased by placing pans filled with water within the incubator and decreased by placing calcium chloride in porcelain pans within the nursery compartment. The eggs were weighed daily to determine the moisture loss throughout the incubation period. Drawings of the air cell were made on the 7th, 14th, and 18th days of incubation. Chicks were weighed in grams 24 hours after hatching to determine the effect of moisture loss on chick weight.

Table 18 shows the effect of variation of relative humidity within the incubator.

Table 18—Effect of variations in relative humidity on hatchability.

Test No.	Relative Humidity			Hatchability	Average Weight per Chick
	1st Period 10 days	2nd Period 10-18 days	3rd Period 18 days to hatching		
	per cent	per cent	per cent	per cent	grams
1	82.0	83	95.5	40	37.56
2	65.5	58	84.7	61	37.60
3	53.8	49	66.0	48	37.64

These data show the depressing effect of extremes of relative humidity on hatchability. The chicks hatched under conditions of 58 to 66 per cent relative humidity for the first 18 days and 85 per cent for the final period were of normal weight; an air cell of proper size was obtained, and a high percentage of strong chicks resulted therefrom. (Bice)

Artificial Illumination for Laying Hens is a Paying Practice

This project has been in progress during the past five years, the data presented being a progress report for the past year. Artificial illumination increased egg production during the fall and winter months when egg prices were at their peak. Body weight was maintained and in a few cases gains were shown. The mortality in Single Comb White Leghorns did not increase over those not receiving lights; however, in every case the mortality of Barred Plymouth Rocks, Rhode Island Reds, and Black Australorps was greater when lights were used. Artificial illumination during the pullet year of lay did not injure the breeding ability of these birds when in their second and third year. Pullets that are hatched in November, December, January, and February have a tendency to go into a partial molt after three or four months of production. Artificial illumination has offset this condition in 75 per cent of the layers. This is of importance inasmuch as the partial molt usually sets in when eggs are at peak prices. Table 19 summarizes the results of the test. (Bice)

Table 19—Artificial illumination versus no artificial illumination for laying hens.

	With Artificial Illumination	Without Artificial Illumination
Egg production	54.6 per cent	46.0 per cent
Cost of light per dozen eggs	$ 0.005	
Feed cost per dozen eggs	$ 0.179	$ 0.156
Mean weight per dozen eggs	22.5 ± .08 oz.	22.00 ± .09 oz.
Mean body weight at beginning	3.18 ± .028 lbs.	3.234 ± .035 lbs.
Mean body weight at end	3.73 ± .039 lbs.	3.76 ± .045 lbs.

Confinement of Poultry Solves some Problems and Presents Others

Housing and its effect on poultry is one of the most important problems with which the poultrymen of the Territory are directly concerned. Hawaii, on account of disease, insects, parasites, and weather conditions, requires somewhat different

housing conditions than those on the mainland. This fact has long been recognized and poultry houses of today show vast improvement over the old houses of ten or fifteen years ago. This improvement in the housing of poultry in Hawaii has not been sufficient to completely control mortality, but certain poultry diseases such as coccidiosis and roup have been markedly abated. Parasitic infestations, such as round and tapeworms, have likewise been reduced; but other, and sometimes more disastrous troubles such as cannibalism and "perosis" or "slipped tendon" have made their appearance. Therefore, the major considerations of this study are the effects of different degrees of confinement on poultry of various ages. Special attention is being paid to the rate of growth, cannibalism, disease, egg production, and reproduction.

Colony houses. Four groups of chicks were started in 10 ft. x 12 ft. colony brooder houses to prevent overcrowding and to provide sunlight for the chicks. These runs are 12 ft. x 20 ft. and are of two different types. One type has removable wire panel floors, and the other has concrete floors with tar paper covered roofs. All houses are screened throughout to control fowl pox. The chicks were started on a 5 per cent molasses-all-mash ration. To insure against the occurrence of "perosis" no minerals were added to the ration. The cockerels were removed from each pen at the end of the seventh week to allow more room for the remaining pullets. These pullets are to be transferred to the wire-floored laying houses at the end of the twelfth week for the next phase of the confinement experiment.

Battery brooders. Four groups of chicks were also started in specially constructed wire-floored battery brooders 4 ft. by 16 ft. These are located in a remodeled laying house. Cel-o-glass, a red translucent material reinforced with wire screen, is used in front of the windows so that all light entering the brooder room passes through it. This is done to prevent and control cannibalism. These chicks were also started on a 5 per cent-molasses-all-mash ration and were similarly managed except for housing. (Bice)

Molasses Being Tried in Chick and Fattening Rations

As molasses is a locally produced, cheap feedstuff, it is important that efforts be made to determine to what extent it can be incorporated into Hawaiian poultry rations. Work is being carried on in all phases of poultry management to determine the optimum amount of cane molasses in chick, growing, laying, and breeding rations. At present this carbohydrate feed is being tested out in chick and fattening rations.

Three lots consisting of over 100 chicks each have been fed molasses added in varying proportions to an all-mash chick ration. The lots and rations used in this test are listed in the table below:

Table 20—Proportion of cane molasses used in feeding tests and cost of the molasses-mash mixture.

Lots	Cane Molasses Added to Chick Mash	Estimated Cost of 100 lbs. of Mixture
	per cent	
1	3	$2.80
2	5	2.77
3	0 (check)	2.85

The weekly weights of fifty individual birds in each lot were taken to determine the average weight. After the sexes were distinguishable, twenty-five of each were weighed and the average weekly weight determined for each sex. The cockerels were removed at the end of the seventh week to make more room for the pullets. In the fattening experiments which have just begun, an endeavor is being made to ascertain to what extent molasses will replace ground whole corn meal in the standard poultry fattening ration. (Bice, Tower)

Cross Breeding for Meat and Egg Production

This project was started in April when eight pens of birds were mated. These birds are housed in specially constructed pens and have access to free range. The following shows the various matings: (1) Barred Plymouth Rock x Japanese Game; (2) Rhode Island Red x Japanese Game; (3) White Leghorn x Japanese Game; (4) Black Australorp x Japanese Game; (5) Japanese Game x Japanese Game.

The day old chicks were examined individually for any sex-linked character which might aid in sex determination, such as length of primary flight feathers, color of down markings, color of beaks, shanks, and toes, tail development, and type of comb. The chicks were also examined each week to note the type and rate of feathering. Nothing can be definitely said about these observations on the day-old chicks until the sexes are distinguishable.

These different lots of crossbred chicks are being brooded in a remodeled "warm-shaft" brooder with one-half inch mesh wire floors to control coccidiosis. The ration is an all-mash ration and to insure against perosis no minerals are added. The chicks will be kept in this brooder until danger of coccidiosis has been passed, at which time the males will be placed in other quarters until they are ready for fattening tests. The pullets will be placed in other pens where they will be grown out to maturity and production tests run next year to see how they compare with the pure varieties of fowls.

Mortality up to date has been very low. The different crosses compare favorably with the pure breds, though White Leghorn and the Rhode Island Red hybrids at this time appear to be the best cross. Compared with pure Reds and Leghorns at the same age, they are heavier and seem to have more vigor and vitality. (Bice, Tower)

PARASITOLOGY

POULTRY PARASITES

The Gizzard Worm of Chickens and Turkeys

The gizzard worm, *Cheilospirura hamulosa*, was first recognized in Hawaii a few years ago, and it is now well known among most of the poultry raisers of the Territory. During field investigation this parasite was noted on the islands of Kauai, Oahu, Maui, and Hawaii. The losses due to gizzard worm have not been estimated, but considerable emaciation and anemic conditions have been noted in birds heavily parasitized. One poultryman reported that in the past few years practically 100 per cent of his birds were infested. During a recent field survey on one of the islands, 18 out of 32 chickens examined at necropsy were infested with gizzard worms.

New intermediate hosts for the gizzard worm have been found. Previous to this investigation only grasshoppers were known to serve as intermediate hosts for the chicken gizzard worm. However, poultrymen in Hawaii and in the continental United States have reported gizzard worm infestation in chickens which apparently did not have access to grasshoppers. These reports indicated the likelihood of other carriers responsible for the transmission of the parasite.

In the present investigations it has been experimentally shown that 14 different species of arthropods may serve as intermediate hosts for *Cheilospirura hamulosa.* These athropods are as follows:

(a) Grasshoppers—*Conocephalus saltator*, *Atractomorpha ambigua*, and *Oxya chinensis*
(b) Sand hopper or sand shrimp—*Orchestia platensis*
(c) Beetles—
Flour beetles—*Tenebroides nana*, *Tribolium castaneum*, and *Carpophilus dimidiatus*
Beetles found around poultry manure—*Dactylosternum abdominale*, *Typhaea stercorea*, *Palorus ratzeburgi*, *Euxestus* sp., and *Litargus balteatus.*
Grain and rice weevils — *Oxydema fusiforme* and *Sitophilus oryzae.*

Of the above mentioned carriers only the flour beetle, *Tenebroides nana*, the amphipod, *Orchestia platensis*, and grasshoppers collected in gizzard worm endemic poultry farms have been found naturally infested with gizzard worm larvae. Other arthropods commonly found in poultry farms, namely, house flies, sow bugs, and earwigs could not be infected experimentally.

The complete life cycle of the gizzard worm parasite both in the intermediate hosts and in the chicken has been studied. It has been found that the larvae reaches the infective stage in the intermediate host in about three weeks; after the infective larva is ingested by a chicken it requires about two or three months before it reaches sexual maturity. (Alicata)

INTERMEDIATE HOSTS FOR OTHER PARASITES OF CHICKENS

The spiral stomach worm, Dispharynx spiralis. The sow bug, *Porcellio laevis*, has been found to be a new intermediate host for the spiral stomach worm, *Dispharynx spiralis*, of chickens. On a poultry farm near Honolulu, 72 per cent of sow bugs were found naturally infested with this species of roundworm. In the continental United States two other species of sow bugs, *Porcellio scaber* and *Armadillidium vulgare* were reported as intermediate hosts.

The globular stomach worm, Tetrameres americana. An earwig, *Euborellia annulipes*, a sand hopper, *Orchestia platensis*, a black beetle, *Dendrophilus* sp., and a grasshopper, *Conocephalus saltator* have been found to serve as intermediate hosts for *Tetrameres americana.* The earwig, sand hopper, and beetle were found naturally infested, and the grasshopper was experimentally infected. The only intermediate hosts previously known for this parasite were grasshoppers.

The eyeworm, Oxyspirura mansoni. As in the continental United States, the cockroach, *Pycnoscelus surinamensis*, has been found to serve as intermediate host for eyeworms in local poultry. In two farms near Honolulu, 36 and 74 per cent of roaches have been found naturally infested; in another farm on Maui, 100 per cent of the roaches harbored this parasite. Chickens and ducks have been experimentally infested with eyeworm larvae recovered from infested roaches. Adult parasites were recovered from the eyes of chickens 45 days after experimental infection.

A tapeworm, Hymenolepis exigua. Hymenolepis exigua, a small tapeworm about ½ inch in length previously reported from Japan and Formosa was recently discovered on the island of Oahu. Present investigations have shown it to be transmitted by a sand hopper, *Orchestia platensis.* These sand hoppers are of common occurrence in damp and wet areas in poultry farms. Out of 50 sand hoppers collected on a farm, 32 or 64 per cent were found to harbor infective tapeworm larvae. (Alicata)

Other Parasites of Chickens in Hawaii

In addition to the parasites mentioned above, the following parasites also occur in chickens: Roundworms: *Ascaridia galli*, *Heterakis gallinae*, *Gongylonema* sp., and *Capillaria* sp.; Tapeworms: *Choanotaenia infundibulum*, *Raillietina tetragona*, *Raillietina cesticillus*, and *Hymenolepis carioca;* Fluke: *Brachylaemus* sp.; protozoan: coccidia, several species; arthropods: lice, mites, and fleas. (Alicata)

PARASITES OF PIGS AND HORSES

Two important parasites of the pig, namely, the kidney worm, *Stephanurus dentatus* and the parasite, *Trichinella spiralis*, previously unknown to occur in these islands, have recently been observed. The kidney worm, which damages the liver and kidneys of hogs, has been noted in domestic swine on the island of Oahu, and reports have been received of its occurrence in "wild" pigs on the island of Hawaii.

Plate 10.—Inverted intestine (chicken) showing tapeworms Hymenolepis exigua attached to the inside wall (actual size).

Trichinella spiralis has been found to be present in the muscle of "wild" pigs captured on the island of Hawaii. There is also a possibility that it occurs there in the rodent population.

The large intestinal roundworm, *Ascaris suum*, is one of the most common parasites of pigs in this locality; in many places where pigs are raised on clean concrete floors, the incidence of this parasite has been found to be low.

The most common animal parasites found in the local horses are as follows: Stomach parasites: roundworms (*Habronema* sp. and *Trichostrongylus* sp.) and bots (several species). Intestinal parasites: Ascarids (*Parascaris equorum*); the large strongyles or palisade worms (*Strongylus* spp.);

several small strongyles or cylicostomes; tapeworms (2 species); pinworms (*Oxyuris equi*). (Alicata)

LIVER FLUKE

Surveys Show the Liver Fluke to be Widespread in the Hawaiian Islands

Liver fluke infestation in cattle was first reported in the Hawaiian Islands by Lutz[1] in 1892. At that time flukes were reported to be a menace on the islands of Oahu and Kauai; examination of the cattle slaughtered at Honolulu revealed that 298 calves out of 620 and 1,313 cattle out of 2,186 were infested with liver fluke. In 1905 Smith and Van Dine[2], in a report covering six months' kill, showed 990 fluke infested cattle out of 3,376 slaughtered for the Honolulu market. In 1934, Riley[3], formerly of the Department of Zoology, University of Hawaii, estimated that 75 per cent of the dairy animals in Hawaii were infested with liver fluke but the incidence of infestation was much lower in beef cattle. In 1935, Maurice C. Hall, chief of the Zoological Division, U. S. Department of Agriculture, in a preliminary survey, noted liver fluke on Oahu, Kauai, Maui, and Hawaii.

Present field investigations have shown that of the islands investigated Oahu and Kauai show the most numerous infestation in cattle. The most heavily infested areas occur on the windward coastal regions of each respective island. On the island of Hawaii the fluke-infested areas are principally in the vicinity of Hilo among dairy cattle. The island of Maui has a few scattered areas around the Wailuku district and on the coastal regions from Waikamoi to Kipahulu with one small area at Lahaina. Molokai has not been investigated but packing house reports as indicated in Table 21 show liver fluke infestation in cattle. Cattle in Niihau and Lanai have been found not fluke-infested and offer no problem due to the type of agriculture and lack of rainfall. (Swanson)

[1]Lutz, A.—Biennial report of the President of the Board of Health to the Legislative Assembly, Session of 1892, p. 24.
[2]Smith, J. G. and Van Dine, D. H., "The Common Liver Fluke in Hawaii," Hawaiian Agricultural Experimental Press (1905), No. 11, pp. 1-7.
[3]Riley, M. K. Mimeographed article on file at this Station.

Slaughter House Reports of Beef Cattle

The following table gives the percentage of fluke infestation of beef cattle slaughtered in Honolulu during the year of 1935:

Table 21—Proportion of fluke infestation of beef cattle slaughtered in Honolulu during 1935.

Island	Animals killed	Animals Fluke Infested	Animals Not Infested	Proportion of Infestation
				per cent
Hawaii	559	23	536	4.1
Molokai	153	81	72	52.3
Oahu	641	456	185	71.1
Total	1,353	560	793	41.4

Water Buffaloes and Horses also Found Infested with Liver Fluke

In addition to cattle, water buffaloes have been found infested with liver flukes. Local veterinarians have also reported liver infestation in horses.

Several sheep, goats, and deer, which could become infested with liver flukes, have been examined and found negative. Since these animals do not usually range in fluke infested areas, they are probably of little importance as liver fluke carriers. Additional study of wild animals in the upper areas of forest reserves is important inasmuch as, if infested, they may contaminate the water which eventually reaches the lower areas where cattle range.

Methods Used for Control of the Liver Fluke

Eradication of the liver fluke is usually best accomplished by eliminating the snail which serves as the intermediate host. The following are known facts about snails:

Snails do not thrive in brackish water or extremes of acidity or alkalinity.

Snails do not usually appear in swift running rocky streams nor in high mountain streams possibly due to acidity from mountain ferns and the rapid flushing of the streams.

Snails prefer shallow, slow-running or standing water with a marked preference for mud.

From experiences with liver fluke control methods on the mainland, the following procedures have proved a satisfactory means of control but will have to be altered according to conditions prevailing in the islands.

1. *Drainage and fencing followed with copper sulphate-treatment of waters.*

Drainage is preferred and offers the most permanent control but has its drawbacks in these islands as (a) the expense involved as compared to the benefits received does not always compensate for this procedure; (b) some areas cannot be drained due to the fact that they serve as reservoirs for water which is necessary for cane plantations. The sugar industry is first in consideration to the plantations; (c) some areas cannot be drained due to the lack of sufficient fall to the sea.

Fencing of large ponds, reservoirs, or swampy areas which cannot be drained affords the best means of control. Its disadvantages are that it removes from grazing the most productive lands and remains as a constant source of infestation.

2. *Treating water troughs*

Leakage from water troughs produces muddy areas which may harbor snails. Treating water troughs with copper sulphate is to be recommended. Using automatic water cups or providing the water troughs with automatic floats will aid materially in the prevention of leakage.

3. *Filling*

Low swales, holes, etc., may be eliminated by hauling in rocks and dirt or by plowing and scraping in the surrounding earthier materials, leveling same with the contour of land.

4. *Use of drugs*

Results of other workers on the mainland have shown carbon tetrachloride to be very efficacious in treating infested sheep, but cattle, especially dairy cows in milk production, do not generally tolerate the drug even in small doses.

5. *Use of fluke-free grass*

Where cut green forage is fed to animals, it is imperative that it be from liver fluke-free areas. The practice of local dairymen of feeding panicum (*Panicum purpurascens*) and honohono (*Commelina nudiflora*) cut from along streams and

swampy areas should be discontinued since it may be infested with liver fluke cysts. (Swanson)

Field Experiments Now in Progress

Two cooperative experiments have been begun with dairymen on Oahu to determine the feasibility of the drainage method of fluke control. The pastures were first surveyed and ditches so placed that the swampy areas would drain. One experiment required 6,000 feet of ditch. In the other, filling in some swales was likewise necessary.

After drainage operations are completed, the area will be treated with copper sulphate. Fluke-free calves will be confined in the pasture for a period of 60 days and subsequently slaughtered to determine if all sources of infestation have been removed. (Swanson)

Species of Liver Fluke Found in Hawaii

Lutz, in 1892, reported *Fasciola hepatica* as the common fluke occurring in Hawaii. Recently, a group of liver flukes recovered from livers of cattle were submitted to the Bureau of Animal Industry, Washington, D. C.[1] for identification and found to be *Fasciola gigantica.* This fluke is the only species thus far found and whether or not *F. hepatica* occur in these islands remains to be determined. *Fasciola gigantica* has not been previously reported from the Hawaiian Islands; it is known to occur mainly in Africa, India, and the Orient. This species is known to have the same deleterious effect on cattle as that of *F. hepatica.* (Alicata, Swanson)

The Life History of the Liver Fluke, Fasciola Hepatica

The life history of the liver fluke in Hawaii has been found to be as follows: the *adult fluke* varies from 1 to 2 inches in length and is found in the bile ducts of the liver. The *eggs* deposited by the adult parasites pass with the bile into the intestine and eventually out with the manure. If the eggs reach water, a tiny larva known as *miracidium* developes in each of the eggs. At room temperatures of 78 to 82° F. in Honolulu, the miracidia have been found to escape from the eggs in 14 to 15 days. The miracidia being set free in the water swim

[1]Courtesy of Dr. W. E. Price and Mr. A. McIntosh.

about in search of the fresh water snails known as lymnaeids. These snails are about ¼ to ½ inch in length. When the miracidium finds the snail it burrows into the snail body and develops into a *sporocyst* which later forms many *rediae*. These rediae again give birth to a generation of *daughter rediae*. The latter give rise to *cercariae* which eventually escape out of the snail and encyst on vegetation of any kind. Under experimental conditions at a temperature of about 73 to 75° F., 55 days have been found to elapse from the time the snails were infested with liver fluke miracidia to the time cercariae were liberated from the snails. This period probably varies with the temperature. The number of cercariae which are liberated from a single snail varies possibly with the number of miracidia that have entered the snail. In one particular instance, one snail collected in a flukey pasture, liberated during the period of three weeks 762 cercariae. The cercariae which encyst on the vegetation probably remain alive for many months and are infectious if ingested by cattle or other susceptible animals.

The snail which has been found to serve as intermediate host for liver flukes in Hawaii is *Fossaria ollula*,[1] a snail which had not been previously reported as a liver fluke carrier. This snail is very closely related to other snails known to carry liver flukes in other parts of the world. Snails have been collected from the other Hawaiian Islands but have as yet not been identified. (Alicata)

Silage as a Possible Means of Killing Liver Fluke Larvae Encysted on Grass

Preliminary laboratory experiments involving the making of silage from honohono and panicum grasses in 50-gallon barrels have shown this method to be effective in destroying the vitality of the cercariae encysted on grasses. Guinea pigs did not become infested with liver flukes as a result of feeding several hundred cysts recovered from silage three months old. (Alicata)

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[1]This identification was made through the courtesy of Dr. J. E. Morrison and Dr. Paul Bartsch of the United States National Museum, Washington, D. C., from a group of over 5,000 snails which have been collected in flukey pastures on the island of Oahu.

RODENT CONTROL

During the seven months that the Rat Abatement Campaign program has been in operation the following list of studies were inaugurated as time permitted, and are being continued on into the coming fiscal year:

Development and trial of 100 new poison rat bait formulas.

Selection of attractive food materials for poisoned bait preparations.

Bait preparation trials in the laboratory to ascertain the preference of rats and mice.

Lethal dose studies to determine the amount of poison necessary to kill rats, mice, and mongoose.

Development and trial of a number of new types of live rat traps for collecting animals for laboratory experiments.

Study of rat infestation and damage in and about the Hawaiian Macadamia Nut plantation.

Life habit studies.

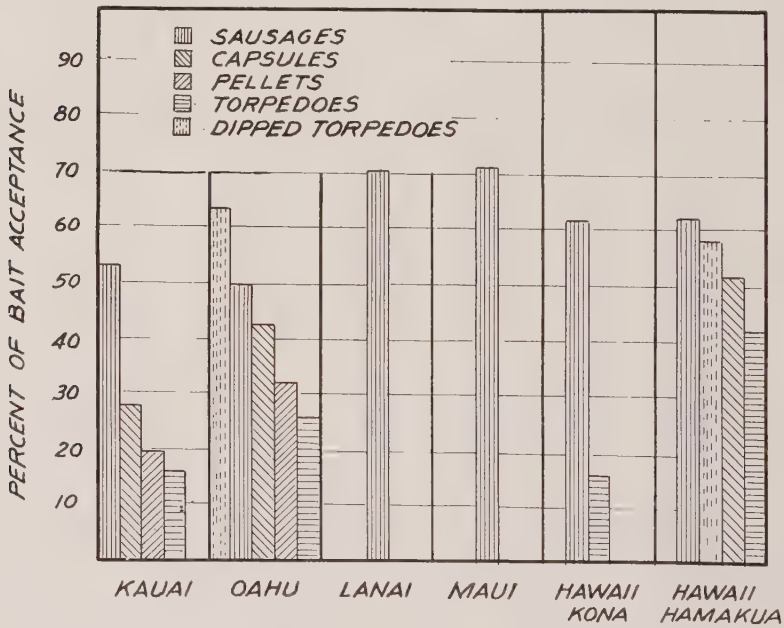

Figure 4.—Relative effectiveness of different poison bait types in rodent control. Sausage baits contained hamburger, bacon, bacon rind, salt pork and blood singly and in various combinations. Capsule baits contained wheat, barley or oats. Pellet baits contained breakfast rolled oats. Torpedo baits contained wheat or barley. Dipped torpedo baits — Torpedo baits dipped in paraffin, corn oil, linseed oil or a nut oil.

New Poison Baits More Efficient Than Those Formerly Used

Through the above-mentioned studies the research staff of the Honolulu laboratory has learned something of the difficulties and reasons for the low efficiency of the poisoned grain and other baits used by various agencies in the control of rats in the cultivated fields in past years. The toxicity of the bait put up in torpedo form was too low to always give the desired kill, and the attractiveness of the bait package was not sufficient to entice the rats to eat a lethal dose. Substituting more preferable bait materials and a more enticing bait package immediately increased the acceptance and efficiency of the poison. Figure 4 shows the difference in acceptance of various types of bait during the period January 1 to July 31, 1936. The figures given for each island represent the average of all forms of food material used in each bait type.

As the sausage type of bait containing some kind of animal tissue as food material appeared much superior to the com-

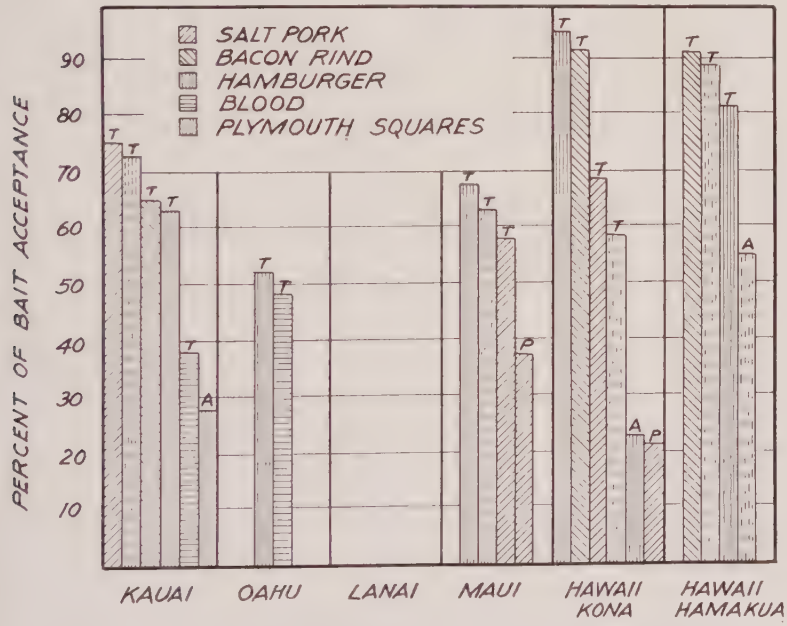

Figure 5.—Relative effectiveness of different food materials and poisons in rodent control. All baits were of the sausage type. The poison used are designated in the figure as follows: T—Thallium sulphate; A—Arsenic trioxide; P—Zinc phosphide.

monly used torpedo type containing wheat or other cereal, various kinds and combinations of animal material were prepared in sausage form and subjected to extensive trial in the field.

Figure 5 gives a comprehensive picture of the acceptance of five different types of sausage bait and three kinds of poison on the six larger islands of the territory. (Garlough, Spencer, Jordan)

Field Operations

To cope with the extensive rat problem in the territory, research and operational units of the rat campaign project with headquarters at the Hawaii Experiment Station in Honolulu have been established in the Hamakua and Kona districts of Hawaii and at Lihue, Kauai. Cooperation of other agencies on Maui and Lanai has also been solicited for assistance in investigation of control measures.

Trapping, poisoning with gas, and land clearing have been the major methods applied for controlling rats in the territory.

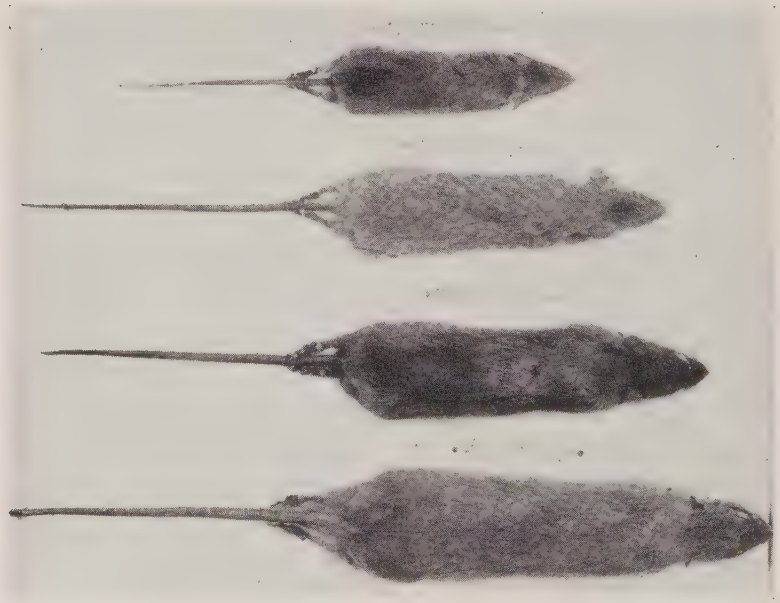

Plate 11.—The four species of rats present in Hawaii. 1. Rattus hawaiiensis. 2. Rattus alexandrinus. 3. Rattus rattus rattus. 4. Rattus norvegicus.

In Hamakua, Hawaii, trapping operations are carried on by the Territorial Board of Health. Land clearing for rat control is being exercised on Maui for plague control by the U. S. Public Health Service. Poison bait is being distributed as a separate control measure as well as in conjunction with the above-mentioned methods over the territory.

The following table gives a condensed summary of the production and shipment of poisoned rat bait from the Rat Abatement Laboratory in Honolulu for research and control operations over the territory for the quarter April 1 to June 30, 1936. Shipments prior to this were in small quantities.

Table 22—Showing Kind and Amount and Allocations of Poison Baits Prepared in the Honolulu Laboratory, for the period April 1 to June 30, 1936.

Description of Bait			Locality					
			Hawaii					
Bait type	Food Material	Poison	Hamakua	Kona	Maui	Lanai	Kauai	Total
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Sausage	Hamburger	Thallium sulphate	497	13	257		6	773
Sausage	Hamburger	Arsenic trioxide		13				13
Sausage	Bacon rind	Thallium sulphate	30	24		28	10	92
Sausage	Bacon rind	Arsenic trioxide	12				7	19
Sausage	Bacon (Plymouth Squares)	Thallium sulphate	20	20	24	56	8	128
Sausage	Bacon (Plymouth Squares)	Arsenic trioxide	20					20
Sausage	Bacon (Plymouth Squares)	Zinc phosphide					8	8
Sausage	Salt pork	Thallium sulphate		24	16	28	8	76
Sausage	Salt pork	Zinc phosphide		10	8			18
Dry mix torpedoes	Blood barley	Thallium sulphate	3597	20	125		18	3760
Sausage	Blood oats barley	Thallium sulphate				20	10	30
Dry mix torpedoes	Coffee barley	Thallium sulphate					14	14
Total			4176	124	430	132	89	4951

REPORT OF THE SUBSTATIONS

KONA SUBSTATION

The superintendent has been responsible for the maintenance and expansion of the work on the Substation grounds, has supervised the cooperative field experiments conducted by the Station with various growers in Kona and the Waimea District, and has assisted departments of the Station, the U. S. Bureau of Entomology and Plant Quarantine, and others in making contacts and securing planting material, fruit fly parasites, and the like.

The experimental work at the Kona Substation may be divided into three classes: (1) cultural requirements of tropical fruits and nuts; (2) investigations of the best methods of propagating tropical fruits and nuts; and (3) study of coffee, fruit, and nut varieties.

Macadamia nut. Early attempts to graft macadamia seedlings one to two years old gave poor results when the seedlings were grown in one-gallon cans. During the past year it has been found that when the seedlings were grown in the field nursery, 80 per cent of the grafts were successful. Grafter macadamia trees have fruited 20 months after grafting, whereas the seedlings were four to six years of age before they began to bear. The Sugar Processing Tax Funds have made possible a considerable expansion in the Station's work on selection, vegetative propagation, and cultural methods. Recently over 50 pounds of macadamia nuts were planted and these have already started to germinate. There were also over 500 rough nut seedlings grafted, using three methods, namely, wedge graft with tops on, wedge graft with tops off, and bench grafting. Three top-working experiments containing 50 trees each were also laid out. Twenty-one trees in each of these plots have already been grafted using cleft, wedge, and bark grafts.

Coffee. Cooperative field experiments are being continued with coffee growers. These comprise three fertilizer experiments, two pruning experiments, and one experiment to determine the cause and methods of control of coffee dieback. Recently a number of farmers have adopted a fertilizer formula

based on the results of the Kainaliu fertilizer experiment of the formula 8 per cent nitrogen, 5 per cent phosphoric acid, and 3 per cent potash and have obtained good results.

A beginning was made in the selection of superior coffee strains, the study of the possibilities of vegetable propagation of coffee, and the suitability of different varieties for root stocks. There are now growing at the Station 45 Margogipe seedlings, 70 Guatemalan, 38 Hawaiian, 21 Columnaris, 3 Liberian, and 3 Excelsia as permanent trees. Aside from these there are 5,000 Guatemalan seedings, 75 Liberian, 20 Columnaris, 150 Robusta, and 10 Hawaiian to serve as root stocks for our grafting work.

Fruit trees and vines. The following citrus varieties are now growing in the Station orchard: Mexican lime, Tahitian lime, Italian citron, Ponderosa lemon, Siamese pomelo, Sweet Shaddock, and Wilder oranges. These are doing nicely and more trees of other varieties will be added to the orchard. Much interest in citrus growing, particularly limes and grapefruits, is being shown in the Territory, due to the excellent quality and good demand for the locally grown fruits.

The following varieties of avocado are now growing at the Station: Nabals, Linda, Roy, Beardslee, Sexton, Ilialu, Benik, MacDonald, Kaguah, Haley, Fuerte, Dry, and Lewis. At the present time, nine trees have come into bearing. Conditions in Kona appear to be ideal for growing avocados. Even at the 4,000 foot elevation where avocados were planted several years ago the trees have done well.

Other fruits and nuts which are growing at the Station are as follows: Cashew Nut (*Anacardium occidentalis*), two trees. The flowers have been attacked by a fungus similar to the one which attacks the mango, indicating the desirability of a drier region for the Cashew. Sabucaia (*Lecythis sabucaja*), valuable for its rich edible nut. Breadfruit (*Artocarpus incisa*), five Samoan varieties are doing well. Passion Fruit (*Passiflora edulis*), the purple passion fruit makes vegetative growth but requires a high trellis for good fruiting. Yellow Passion Fruit (*Passiflora edulis forma flavicarpo*), this variety produced a total of 644 pounds of fruit from 28 plants at the Substation.

Lanzone (*Lansium domisticum*), a rare tree in Hawaii. It made very slow growth the first few years, but this season has grown well. Grapes, 30 varieties were under trial. The Isabella was the only variety that did well while the others were failures. Litchi (*Litchi chinensis*), the two varieties, San Hing and Haak-Ip, are now growing. Mites are a serious pest and must be controlled by frequent spraying. Figs (*Ficus carica*). There are two varieties of figs, the Kadota and Black Mission, now growing here. They have done very well, and many cuttings were obtained from these trees for distribution this season. Cherimoya (*Annona cherimola*). There are four varieties at the Station and all are doing well. (Pahau)

HALEAKALA SUBSTATION

Mr. H. F. Willey resigned as superintendant of the Haleakala Substation, December 31, 1935. His successor, Mr. Robert Lyman, was appointed effective July 1, 1936. Work on active projects has been restricted largely to potato variety trials and to maintenance of the permanent grass plots and trees. Plans were developed for numerous changes in the physical lay out. The windbreak and road system are to be changed to provide rectangular plots, more desirable for experimental purposes. Using WPA labor, a road was partially built across the large gulch, thus connecting the 12 acre west section with the main part of the Substation grounds. Arrangements were completed for the piping of irrigation water to certain of the plats to be used for truck crop investigations. Cooperation was initiated with the Pineapple Producers Cooperative Association, whereby certain plots and facilities will be made available for pineapple experiments.

PUBLICATIONS

STATION BULLETINS

No. 74—*The Edible Passion Fruit in Hawaii* by W. T. Pope. 21 pages. A general treatise which gives the botanical relationships and describes the most important species of Passiflora tried locally . The cultural methods treat of selection of site, propagation, use of trellises, fertilization and pruning. The numerous uses of the passion fruit juice are listed.

No. 76—*Factors Affecting the Chemical Composition of Pasture Grasses*, by D. W. Edwards and R. A. Goff. 31 pages. A technical bulletin giving the results of an investigation on Parker Ranch, Island of Hawaii. A series of grasses grown under widely different climatic conditions was harvested at bimonthly intervals. Chemical analyses of certain mineral constituents show the effect of species, season and location on mineral compostion.

No. 77—*Some Fruits of Hawaii, Their Composition, Nutritive Value and Use*, by Carey D. Miller, Katherine Bazore, and Ruth C. Robbins. 133 pages. A general bulletin, giving technical and non-technical information regarding 24 of the most important and widely used fruits in Hawaii. The non-technical information includes descriptions, pictures, uses, and recipes. The technical phases include vitamin and chemical analyses, numerous tables arranging the chemical data for use in dietary calculation.

Annual Report of the Station for 1935, by J. M. Westgate. 28 pages.

TECHNICAL PAPERS

Bilger, Earl M. and Hibbert, Harold — "*Mechanism of Organic Reactions: Pyrolysis of Esters and Acetals.*" *Jour. Amer. Chem. Soc.*, vol. 58 (1936) No. 5 pp. 823-826.

Henke, L. A.—"*Results of Feeding Sprouted Oats to Correct Sterility in Cattle and Swine.*" *Jour. Agr. Res.*, vol. 51 (1935) pp. 51-61.

Henke, L. A.—"*Is Fecundity in Swine Inherited?*" *Jour. of Heredity*, vol. 26 (1935) pp. 455-456.

Henke, L. A.—"*Possibilities of Enlarging and Improving Our Beef Industry in Hawaii.*" Proceedings of the 55th Annual Meeting, Hawaiian Sugar Planters' Association (1935) pp. 110-116.

Magistad, O. C. and Farden, C. A. and Baldwin, W. A.—"*Bagasse and Paper Mulches*," *Jour. Amer. Soc. Agron.*, vol. 27, No. 10 (1935) pp. 813-825.

Wilsie, C. P.—"*Seed Production Studies with Legumes in Hawaii.*" *Jour. Amer. Soc. Agron.*, vol. 27, No. 10 (1935) pp. 784-790.